No. 58. January 1876. [2s. 6d.

THE POPULAR

Science Review

EDITED BY HENRY LAWSON, M.D.

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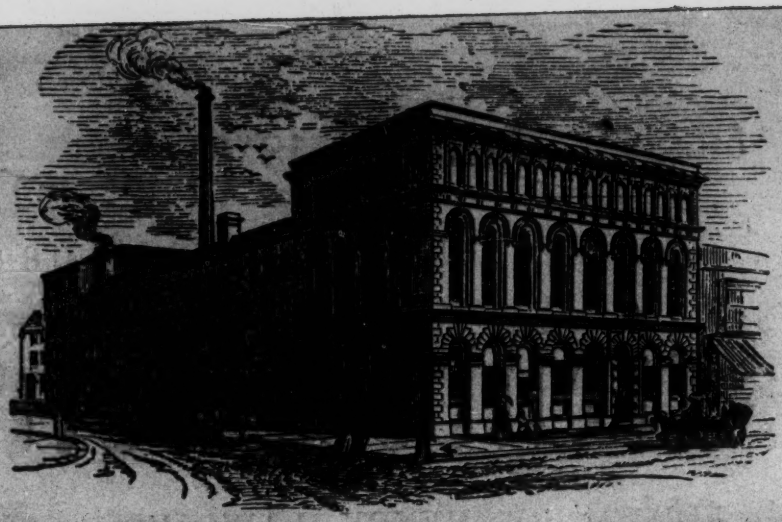

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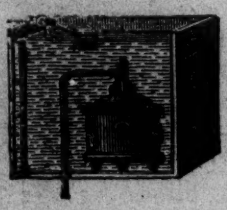

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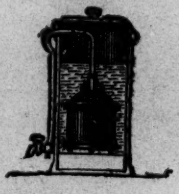

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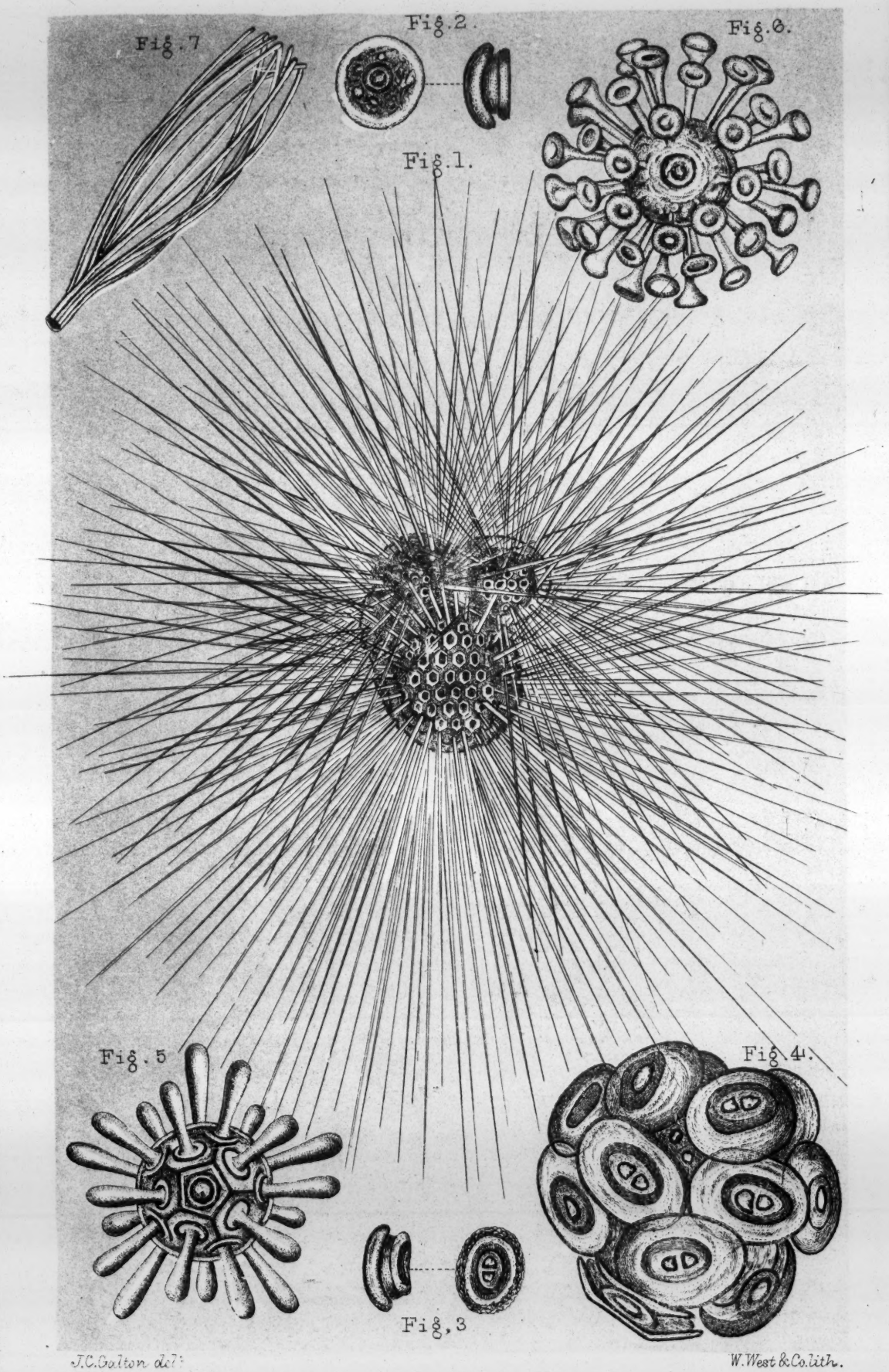

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From the CHALLENGER'S Dredge.

POPULAR SCIENCE REVIEW.

IN THE WAKE OF THE "CHALLENGER."

By JOHN C. GALTON, M.A. (Oxon), F.L.S.

PLATE CXXIX.

"Sie est die einzige Künstlerin: aus dem simpelsten Stoffe zu den grössten Contrasten; ohne Schein der Anstrengung zu der grössten Vollendung; zur genauesten Bestimmtheit immer mit etwas Weichen überzogen, ... ihre Werkstätte ist unzugänglich."

GOETHE, *Die Natur*, 1780.

"Geheimnissvoll am lichten Tag,
Lässt sich Natur des Schleiers nicht berauben,
Und was sie deinem Geist nicht offenbaren mag,
Das zwingst du ihr nicht ab mit Hebeln und mit Schrauben."

GOETHE, *Faust*, 1er *Theil*, 1801.

"Was man an der Natur geheimnissvolles pries,
Das wagen wir verständig zu probiren,
Und was sie sonst organisiren liess,
Das lassen wir krystallisiren."

GOETHE, *Faust*, 2ter, *Theil*.

DOCTOR FAUSTUS, seated among his dusty tomes, his crucibles, retorts, and limbecks, speaks with becoming reverence of the secrets of Nature, which, it appears, he has only attempted to induce her to yield up by employment of the art of the alchymist; while his former pupil, the priggish Wagner, flushed may be with his success in creating the "Homunculus," treats of these same secrets with a somewhat flippant tongue. Nowadays, in these matter-of-fact times, we, but with no diminished regard for Nature, gently, but firmly and with confidence, exact of her tribute from those of her treasures which she has buried fathoms deep, beneath the waves of the ocean, not strictly perhaps "with levers and with screws," but with dredge, trawl, and sounding-lead.

The first successful attempts to ascertain the nature of the sea-bottom and the limit of life at depths greater than 100

fathoms were made by Sir J. Ross, in 1818, who, by the help of a machine of his own invention, brought up several pounds of mud from 1,050 fathoms, or above 1¼ mile, in Baffins Bay, 72° 30′ N., 77° 15′ W. This deposit was described by Ross and Sabine, who accompanied him. It was a fine greenish mud, but no accurate determination of its nature was made. Ehrenberg, in 1853, examined the surface scum and mud obtained by Penny in 73° and 74° N., and found it to consist of—(*a*) Diatoms (vegetable) living at the surface; (*b*) Radiolaria (animals), also surface-living; and (*c*) sponge-spicules (animal), from the bottom. In 1854, Bailey determined the nature of the mud procured by Brooke in 900–2,700 fathoms in the Sea of Kamschatka. The mud was purely silicious, there being absolutely no calcareous organisms. These and other observations tend to establish the existence of a circumpolar zone of silicious deposits in the Arctic regions, within the parallel of 55° N., viz. a *North Polar silicious cap*. In 1839 an Antarctic expedition was despatched under Sir J. Ross, attention having been awakened by the appearance of Ehrenberg's work on minute organisms ("Die Infusionsthierchen"), from the years 1836–38. This naturalist discovered that organisms whose skeletons resembled those occurring in the cretaceous and tertiary rocks, and sometimes constitute their whole mass, are still living. The observations of Dr. Hooker and of Sir J. Ross at two distant points of the Antarctic zone proved the existence of a *South Polar silicious cap*. The discovery of an *intermediate zone* of *calcareo-silicious* deposit, in about 110° lat., of a deep sea sediment, dates back to 1853, and is due to Ehrenberg's examination of soundings brought up by Berryman from 2,000 fathoms, between Newfoundland and the Azores. These consisted of silicious diatoms, *Radiolaria*, and sponge-spicules, as in the Antarctic seas, but the bulk was calcareous *Foraminifera*. From this Ehrenberg concluded that "chalk is nothing but a mass of dead foraminiferal skeletons." These results have been confirmed by Bailey, Huxley, and others, as well as the fact of the extension of a similar deposit over the South Atlantic and into the Indian Ocean. The geological nature of the greensand deposit formations was determined by Ehrenberg in 1854; and the discovery of newer greensand deposit, in 100–300 fathoms was made almost contemporaneously by Pourtales. Parker and Jones, too, ascertained that a formation of greensand was going on in the Australian seas. It is in extending some of the conclusions already established, and in the discovery of much that is wholly new to science, that the *Challenger* has been for the last three years employed.*

* These preliminary remarks regarding the discoveries of Ehrenberg and others are taken from a lecture by Prof. Huxley, "On the Recent Work of

The objects of the expedition are perhaps best expressed by the following abstract from the "Scientific Orders" of the *Challenger*:—"The principal object of the proposed expedition is understood to be to investigate the physical and biological condition of the great ocean basin."* The route proposed was as follows:—Down the coast of Portugal and Spain; across the Atlantic, from Madeira to the West India Islands; thence to Bermuda, then to the Azores, Cape de Verde Islands; along the coast of South America, across the Atlantic to the Cape of Good Hope. Thence by Marion Island, the Crozets, and Kerguelen's Island, to Australia and New Zealand, going southward *en route*, opposite the centre of the Indian Ocean, as near as may be, with convenience and safety, to the southern ice-barrier. From New Zealand, through the Coral Sea and Torres Straits westward, between Bali and Lombok; thence through Celebes and South Seas to Manila. Then eastward into the Pacific, visiting New Guinea, New Britain, and the Solomon Islands. Afterwards to Japan, where some time might be profitably spent. Thence the course should be directed across the Pacific to Vancouver's Island, southerly through the eastern trough of the Pacific, and then homewards round Cape Horn. Special attention must be paid to the fauna and flora of Marion Island, Crozets, and Kerguelen's Islands, and of any new groups to be met with in the region to the south-east of the Cape of Good Hope. If possible, the Aucklands, Campbell, and Macquarie Islands should be touched at. The zoology of the sea between New Zealand, Sydney, New Caledonia, and the Fiji and Friendly Islands should be carefully investigated, as it is possible that the Antarctic fauna may be found here at accessible depths.

Physical Observations.—These are to be made at stations the position of which have been carefully determined, and chosen, so far as possible, at equal distances apart. At each station should be noted the time of the observation, the weather, the temperature of the surface of the sea, the depth, and the bottom temperature, by means of two Miller-Casella thermometers,† with the specific gravity of both the surface and of the bottom water. The nature of the bottom is to be determined by an apparatus to bring up samples, and, if possible, by the dredge. When practicable the amount and nature of the gases contained in the water should be determined. In the path of

the *Challenger* Expedition and its bearing on Geological Problems," delivered at the Royal Institution, on Friday evening, Jan. 29, 1875.—See "Proc. Royal Inst.," vol. vii. part 5, April 1875.

* "Nature," vol. vii. pp. 191 and 252.

† This instrument, and its copper case, are figured at pp. 291, 292 of Prof. Wyville Thomson's "Depths of the Sea," Lond. 1873.

currents *serial* temperature should be taken, either with the instrument of Siemens'* or with a Miller-Casella thermometer. Simple determination of the depth of the sea at regular distances is of primary importance.

The surface temperature of the sea as well as of the air (determined by dry and wet bulb thermometers) is to be recorded every two hours. The records obtained should be reduced to curves.

In the North Atlantic there seem to be the following strata :—

(*a*) *Superficial*, of which the temperature rises with the atmosphere. This does not exceed 100 fathoms in depth.

(*b*) An *upper* stratum beneath this; the temperature of which slowly diminishes as the depth increases to several hundred fathoms. In the higher latitudes this is considerably *above* the normal of latitude, but in intertropical regions it is considerably below the normal.

(*c*) A stratum in which the rate of diminution of temperature is rapid, after being 10° in every 200 fathoms.

(*d*) The whole of the deeper part of the North Atlantic below 1,000 fathoms is believed to be occupied by water not many degrees above 32° Fahr. The *glacial* stratum.

An interesting question is the extent to which colder, and therefore heavier, water may run *up-hill* on the sides of declivities. The position of the Azores is favourable for the determination of this.

The greatest results are expected from the Southern Ocean. The specific gravities of surface and of bottom water are to be compared, and that of intermediate depths, when serial soundings are taken.

The degree of transparency of the water should be determined by Siemens' photographic apparatus, and by lowering a white plate to measured depths.

Observations should be made on the relation, discovered by Professor Schouw, between barometric height and the latitude of the observation. It seems that there are certain meridians of high and of low pressure.

The thermometer and barometer should be observed every two hours. Tidal observations may be made by means of a graduated pole.

It is desirable, when enough tidal observations have been made, to settle the mean level of the sea, and that a permanent beach-mark should be established, recording the date and height above such mean level.

Samples of sea-water should be collected at various depths.

* Mr. Siemens' instrument is very useful for serial measurement, as it does not require to be hauled up for each reading.

A portion is then to be boiled *in vacuo*, the gases collected, and their volume determined, part being hermetically sealed in glass tubes. The gases contained in the air-bladder of certain fishes should be examined.

Botany.—The duties of the botanist are twofold: 1. To collect. 2. To make observations on the life, history, and structure of certain plants. The vegetation of oceanic islands is of especial importance, these being sometimes the last position of flora of great age, which are liable to be speedily exterminated, as at St. Helena. A collection should be made from each islet of a group, as the floras of contiguous oceanic islands are wonderfully different. Among islands of which the flora is absolutely or almost unknown are:—Fernando de Noronha; Trinidad and Martin Vaz, off Brazil; Socotra; Prince Edward I.; Crozets; Marion I.; Pitcairn, Bounty and Macquarie Islands. With regard to the Indian Archipelago, Java alone has been explored, and the Philippines but partially. Collections from islands east of Java, especially Lombok and New Guinea, would be very valuable. The part played by icebergs in the transportation of plants is of importance, and the algæ in hot-springs should be examined.

Zoology.—The littoral fauna of the Papuan shores of Torres Straits is important for comparison with the fauna of the opposite Australian shore.

A hydrographical examination should be made of "Wallace's line" in the Malay Archipelago, and of the littoral faunas on either side of it. Soundings should be taken in the Celebes Sea, Capt. Chimmo having found in 2,800 fathoms a mud bottom of *Radiolaria* and sponge-spicules, but no calcareous organisms.

A line of soundings between Japan and Vancouver's Island, and between the latter and Valparaiso, would be useful for investigation of the quadrant-like zone of the Pacific which separates the eastern boundaries of the Polynesian archipelago from the coast of Northern Asia and America.

The limitation of reef corals should be investigated. It has been suggested that the limit of twenty fathoms may be a thermal one. Specimens of the hair of unmixed races of men should be collected.

Before entering generally and in detail into the results of the expedition, so far as they have been accomplished, it will be interesting to follow, as best we can, in the wake of the gallant ship during her cruise, picking up such "flotsam and jetsam" as may be accorded to us.

At 11.30 A.M. of Dec. 21, 1872, H.M.S. *Challenger* cast off the jetty at Portsmouth. There was a strong breeze blowing from the S.W., and the storm-drum was hoisted. This ship,

liberally lent by Government for the purposes of science, is a spar-decked * corvette of 2,000 tons' displacement, her tonnage being greater than that of all the other ships together which formed the expedition of Cook in 1772. Sixteen out of the eighteen 68-pounders which formed her armament had been removed, so that the main deck was almost clear for scientific action. Besides private cabins there is a commodious zoological workroom (see Fig. 1), a chemical and physical laboratory, and a dark room and working room for the photographers. The weight of the ship is so great that there can be no "give and take" between it and the dredge, tending thus to jerk the latter off the ground. This will probably be met by using a rope of a length greatly in excess of the depth to be explored, and by attaching weights to it. Dredging and sounding are to be carried on from the mainyard, and not, as in the cruise of H.M.S. *Porcupine*, from a derrick at the bow or stern.† A strong pennant is attached by tackle to the end of the yard, a compound arrangement of fifty-five Hodges' "accumulators" ‡ being hung to the pennant, and beneath it is a block through which the dredge-rope is run. This arrangement is better than dredging from a derrick.

The navigation of the ship was under the charge of Captain Nares, R.N., Professor Wyville Thomson being at the head of the scientific staff, which consisted of Mr. H. N. Moseley, M.A. (Oxon), as botanist; the late (unfortunately) Dr. Rudolf von Willemoes-Suhm, a distinguished pupil of Professor von Siebold, of Munich, as zoologist; Mr. Buchanan as chemist; Mr. Murray as geologist; and Mr. Wild as artist and private secretary to the director of the scientific staff.

With regard to the furniture of the zoological laboratory, §

* This is an advantage, according to Professor Wyville Thomson.—"Nature," vol. vii. p. 386.

† This arrangement is figured in Professor Wyville Thomson's "Depths of the Sea," fig. 46, p. 248.

‡ This is figured in an article by W. Lant Carpenter, "On the Apparatus employed in Deep Sea Explorations on board H.M.S. *Porcupine*, in the Summer of 1869."—"POPULAR SCIENCE REVIEW," vol. ix. p. 286. This machine itself is well described in some humorous verses sent to the "Cape Monthly," by one "Jack Skylight":—

"It ain't a bad doge neither; for when it's pulled it stretches,
And gives a kind of surge when the dredge at summut ketches:
It's like a concertina, Bill, but where the wind is squoze,
From end to end a set of stays like Inde-rubber goes;
A block is tacked at bottom, and through it runs the line," &c.

§ See the first of a series of letters sent by Dr. von Willemoes-Suhm to Professor Siebold, which appeared in "Siebold und Kölliker's Zeitschrift," Bänd. xxiii. to xxv. inclusive.

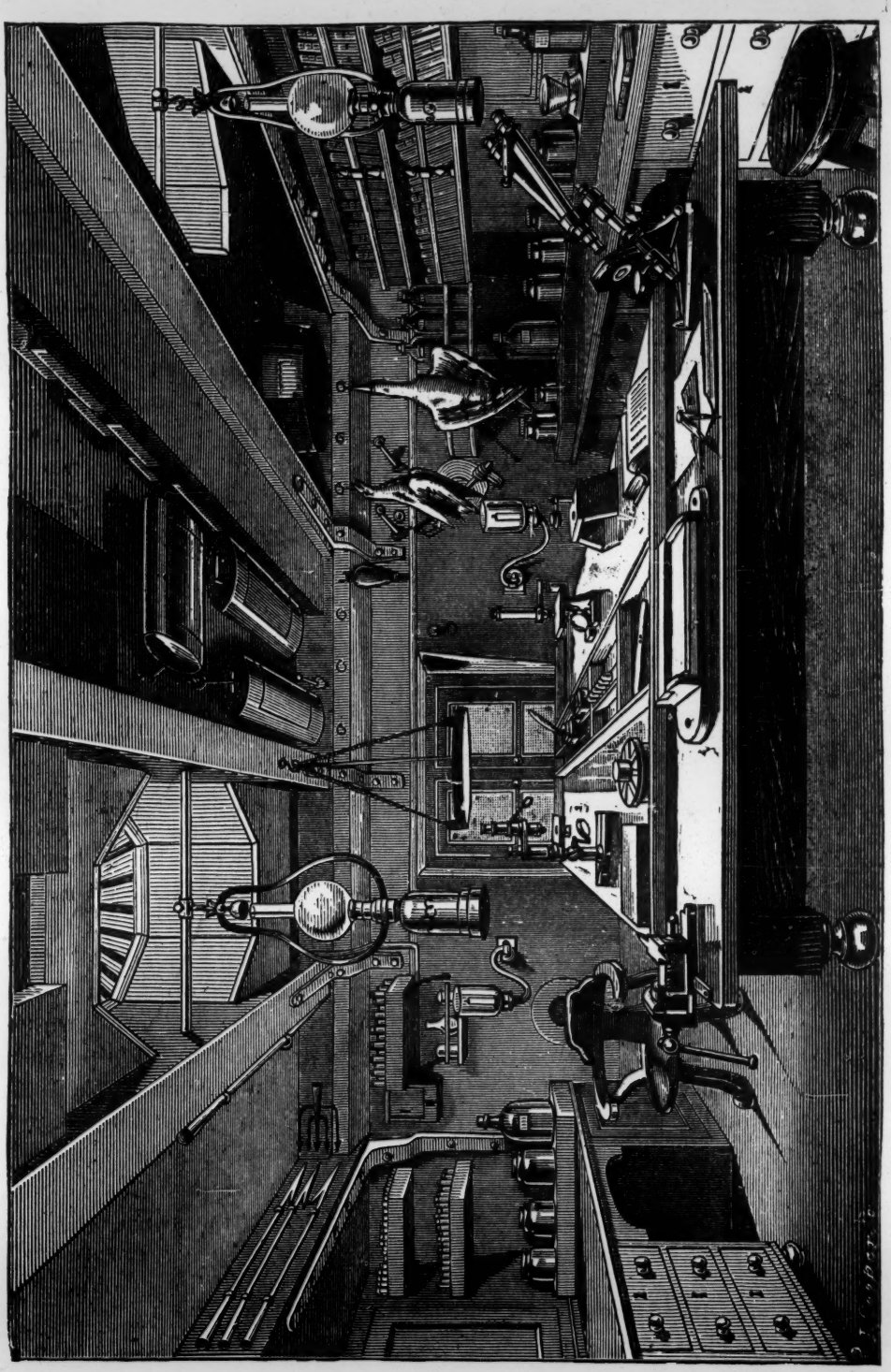


FIG. 1.

the supply of microscopes was most liberal, comprising three of Hartnack's pattern, four of Merz's, one of Winkel's (of Göttingen), a binocular by Smith and Beck, an instrument by Ross, one dissecting microscope by Zeiss, besides simple microscopes for dissecting, lenses, &c. Such instruments as forceps and scissors were plated with nickel, so as to guard against rust—that plague of all steel instruments, either on board ship or in hot climates. These are much to be recommended to all naturalists who work on the sea-coast.*

Of the library the naturalists were not a little proud, including as it does *inter alia* such splendid works as Bronn's "Klassen und Ordnungen des Thierreichs," Milne-Edwards' "Leçons sur la physiologie et l'anatomie comparée," ten volumes of Petermann's "Mittheilungen," Siebold and Köliker's "Zeitschrift," Max Schultze's "Archiv," the "Transactions" of the Linnæan and Zoological Societies, and some volumes of the "Philosophical Transactions," together with such reprints of papers upon the development of marine animals as were the property of individual members of the staff.

The naturalists spent their time generally in the laboratory, until they were hailed by the cry, "The dredge is up," when they rushed on deck, each armed with a forceps, eager to explore the contents of the dredge or trawl. In some respects the trawl was found to be superior to the dredge, as this latter brings up so much mud as to spoil delicate organisms.

For a week the *Challenger* experienced very bad weather in the Channel and in the Bay of Biscay, which, however, was even an advantage, as tending to find out weak points before that it was too late to remedy them. The ship rolls very much —over 35° "when put to it."

Off the coast of Portugal specimens of *Hyalonema* † and *Euplectella* ("Venus' Flower Basket") were obtained with spicules not to be distinguished from those of their representatives in the Philippines. Some fishes were brought up from 600 fathoms off Cape St. Vincent, which were in a peculiar condition from the expansion of the air in their bodies, on relief from extreme pressure, their eyes having a singular appearance, "protruding like globes from their heads." From 1,090 fathoms a gigantic Amphipod crustacean was brought up, of the family *Hyperina*, allied to *Phronima*. The eyes were very remarkable, "extending in two great facetted lobes over the whole of the anterior part of the cephalo-thorax," like the eyes

* They were made by Baker, of Holborn.

† This is beautifully figured in Professor Wyville Thomson's work already quoted, fig. 66, p. 421.

of one form of trilobite.* Some beautiful little urchins were also obtained, allied to the *Salteria* taken by Count Pourtales off Florida. "To an advocate of the 'continuity of the chalk' it is pleasant," says Professor Wyville Thomson, "to see in the flesh this little beauty, which has hitherto been reckoned among the lost tribes."

On Friday evening, Feb. 14, 1873, Santa Cruz was left, the weather being fine, and a light breeze blowing from N.E. Course westward. On the morning of the 17th, from a depth of 2,700 fathoms a mutilated specimen of a new Gephyrean was obtained, which was referred by Dr. Suhm to a new genus, *Leioderma*, intermediate between the Sipunculids and Priapulids. On the 18th, with 2,220 fathoms of line out, there was brought up, attached to a kind of coral, a sponge belonging to the *Hexactinellidæ*, but the type of a new genus *Poliopogon* (πολιός, white; πώγων, beard) *amadou*. Both surfaces were covered with a network of square meshes like that of *Hyalonema*. From its base projected a bush of anchoring spicules, each having a barbed end like the anchors on the skin-spicules of it.

Professor Wyville Thomson remarks † that in hot and calm weather the towing-net is usually unsuccessful, for it seems that the majority of pelagic forms retire during the heat of the day to the depth of a few fathoms, and come up in the cool of the evening and in the morning, and, in some cases, in the night. The larger phosphorescent animals are often abundant during the night around and in the wake of the ship, while none are taken in the net in the day. On the afternoon of the 26th no less than 3,600 fathoms of rope were payed out, the deepest haul by several hundred feet which had hitherto been made. For a few previous soundings part of the mud had been getting darker, having, too, less calcareous matter on analysis, and fewer foraminifera were seen under the microscope. Now the latter organisms were entirely wanting, there being only a clay mud, like chocolate, remaining for days suspended in water. When at last it settled it formed a smooth red-brown paste, with no feeling of grittiness to the fingers, "as though it had been levigated with extreme care for a process in some refined art." It was almost pure clay on analysis, consisting of a silicate of alumina, sesquioxide of iron, with a

* See Dr. Suhm's paper "On some Atlantic Crustacea from the *Challenger* Expedition." "Trans. Linn. Soc.," New Series. "Zoology," vol. i. Pl. XI. fig. 4.

† "Nature," vol. viii. p. 29. A family of silicious sponges with six-rayed spicules.

small quantity of manganese. It would be interesting to know whether this is connected with the extreme depth. Professor Wyville Thomson thinks not. The depth at Station 5 was 2,700 fathoms, and on that occasion foraminifera were abundant, and several bivalve molluscs were captured living. The difference in depth cannot be so effective as to arrest the life of organisms to the secretion of whose testes the grey Atlantic ooze is due. He is inclined to attribute this deposit to a movement of the water from some special locality—possibly the mouths of the great South American rivers.

On Sunday, March 2, the first patches of Gulf-weed were seen. On the morning of the 4th a fine decapod crustacean was caught, having the characters of *Astacidæ*, but differing in the absence of eyes and eye-stalks.* The absence of eyes, remarks Professor Wyville Thomson, in many deep-sea animals, and their full development in others, is very remarkable.†

A singular absence of higher forms of life has been noticed for some days past. "Not a bird was to be seen, from morning to night." More latterly sharks and dolphins have been seen, the latter in pursuit of flying-fish. They are easily deceived by a rude imitation of one of their prey, such as a white spinning bait, when the ship is going rapidly through the water. On the 11th the dredge-line was paid out to more than 4,000 fathoms,

* *Vide* Dr. Suhm's paper "On some Atlantic Crustacea from the *Challenger* Expedition," Pl. XIII., fig. 1. *Willemoesia leptodactyla* is its right name, the generic name *Deidamia*, under which it is figured in "Nature," vol. viii. p. 51, fig. 2, being already the property of a North American genus of *Sphingidæ*. "*The eyes are entirely wanting*, nor is there, as in *Astacus Zaleucus*, any place left open where you might expect them." . . . . "It is very astonishing indeed that, among all crustaceans known to us, *Willemoesia approaches most closely to the fossil Eryontidæ*."

† For instance, a stalk-eyed crustacean from 700 fathoms in which the eyes are well developed in shallow water—*e.g. Ethusa granulata*—may have eye-stalks gradually modified into immovable pointed organs, devoid of special sense, while *Munida* from a like depth has unusually developed and sensitive eyes. "It is possible that in certain cases as the sun's light diminishes the powers of vision become more acute, while at length the eye becomes susceptible of the stimulus of the faintest light of phosphorescence." Absence of eyes is not unknown among the *Astacidæ*. *A. pellucidus* from the Mammoth Cave, in Kentucky, is blind, and from the same cause, but morphologically, the eyes are not wanting, being represented by rudiments, while in *Willemœsia* there is no trace of them or their peduncles. Mr. Wood Mason describes ("Nature," June 5, 1873, p. 111) a macrovrous crustacean, a type of a new genus—*Nephrops Stewarti*—dredged from 250 to 300 fathoms off the east coast of the Andaman Islands, which had lost its organs of vision by disease, but in compensation the anterior and auditory organs were greatly developed. It burrows in mud at the bottom.

nearly five statute miles. A tube-building annelid, making tubes from the sparse gritty matter of the red mud, was brought up. It was allied to the genus *Owenia*, but had no cephalic branchia. "As bearing upon some of the most important of the broad questions which it is our great object to solve, I do not see that any capture which we could have made," says Professor Wyville Thomson, "could have been more conclusive than that of this annelid." The depth was practically 3,000 fathoms, a depth which does not appear to be greatly exceeded in any part of the ocean. The nature of the bottom was very unfavourable to higher animal life, and yet this creature, closely allied to a well-known shallow water group of high organisation —the *Clymenidæ*—was not developed.

In dredging off Sombrero Island, on March 15, several sponges belonging to the *Hexactinellidæ* were brought up, closely allied to those obtained off the coast of Portugal; showing that the distribution of this remarkable order is very wide. Two crustaceans, belonging to the family *Astacidæ*, were also captured, both totally devoid of eyes; the one was a *Willemœsia*,* the other *Astacus zaleucus*.† Both were carefully examined by Dr. Suhm. Where the eye would be seen in *A. fluviatilis* "there are two round vacant spaces which look as if the eye-stalk and eyes had been carefully extirpated, and the space they occupied closed with a chitinous membrane."

On March 16 H.M.S. *Challenger* arrived at St. Thomas, after 30 days' voyage from Teneriffe, having completed 23 stations. The natural history of this island, which belongs to Denmark, is fairly known, large collections having been sent to Copenhagen. Ophiurideans are particularly plentiful here. While dredging for algæ Mr. Moseley brought up some specimens of a flowering plant, apparently *Halophila*; a genus hitherto known only to occur in the Red Sea and in the Indian and Pacific Oceans.‡

St. Thomas was left on the 24th, and the Bermudas reached on April 4, 32 stations having been completed. It may be worth mentioning that on March 26, in sounding at 3,875 fathoms, two Miller-Casella thermometers, which had been sent down, *sicut est mos*, with a ship water-bottle, attached to a "Hydra" sounding instrument, came up broken. The mischief was traced to the giving way of the smaller, unprotected bulb.§ Why should the

* *W. crucifer*, T. L. S., *Ibid.* pl. xii. fig. 10; and "Nature," vol. viii. p. 266.

† T. L. S., *Ibid.* pl. x. fig. 1.

‡ This plant was submitted to Prof. Ascherson of Berlin, who said that it was a congener of *H. ovalis*, and called it *H. Baillonis*. It was found half a century ago by Bertero.—"Journ. Linn. Soc. Botany," vol. xiv. p. 311.

§ A figure of the fragments is given in "Nature," vol. viii. p. 110.

mischief occur here, and how is it to be remedied? It is probable that the end of the small bulb was the last point of the instrument heated and sealed after the tube had been filled with liquid, and that, consequently, the annealing at this point was imperfect. It will be of no use, thinks Professor Wyville Thomson, to protect this bulb in the same way as the large bulb, by an outer shell; the only plan, therefore, is to thicken the small bulb and improve its temper. It should be noted that the instrument had undergone a pressure of four tons to the square inch, though it had only been tested to bear three tons to the same area.*

With regard to the Bermudas, one would imagine at first sight that the islands exhibited on a small scale "an epitome of the geological phenomena of a disturbed palæozoic district." General (when Lieutenant) Nelson, R.E., has pointed out that the great proportion of the Bermudas is formed simply by the blowing up by the wind of a fine calcareous sand, a product of the disintegration of coral, shells, and other constituents of the neighbouring reefs. This sand is blown into dunes 50 feet high ("Æolian formation," Nelson)—see fig. at p. 267, "Nature," July 31, 1873—which move inland, "forming shoreward a glacis at the angle of repose of loose sand." This sand is converted into a rocky material by the agency of rain-water, which, containing a quantity of free carbonic acid, dissolves the lime freely. This solution of bicarbonate of calcium, on percolating, loses again a part of its carbonic acid, and deposits a cement of carbonate between the particles of coral sand. There is a total absence of running water in the Bermudas, nor is there a trace of a pool or even of a ditch; for the rain percolates, as through a sieve, the ground, which is also horizontally porous, thus letting in the salt water also, below the sea-level. The terrestrial vegetation of the Bermudas may, according to Mr. Moseley,† be divided into five principal stations, each having a flora peculiar to itself; viz. 1. To the coast-line, with the littoral flora. 2. Peat-bogs or marshes. 3. Shallow brackish ponds. 4. The caves. 5. The remaining land surface. Along the coast-line there occurs abundantly *Borrichia*, a composite, in two forms, side by side; one with succulent bright green leaves, the other with glaucous and downy foliage. The binding plant of the dunes is a hard prickly grass (*Cenchrus*). In

* It seems that Messrs. Negretti and Zambra had some years previously—in 1857—made upwards of fifty of the same modification of Six's thermometers for the Board of Trade. See their letter in "Nature," vol. viii. p. 529; also a communication, accompanied by a figure, "On a New Deep Sea Thermometer."—"Proc. Roy. Soc." vol. xxii. p. 238.

† "Journ. Linn. Soc. Botany," vol. xiv. No. 77, pp. 317–321.

the marshes the ferns are the great features, especially two *Osmundas*. Here were found nearly all the lichens and fungi. The peat burns well, and has the appearance of its ordinary European representative. In excavating Bermuda dock a bed of lignite was found at 50 feet depth, evidently an ancient peat-bog. In the caves the coffee grows wild, the tree being of large size. The juniper forms the main feature of the vegetation. Common fennel, too, has spread all over the islands. About 160 species of flowering plants were collected in the Bermudas, of which no more than 100 are indigenous. Those of West Indian origin were transported, as Grisebach suggests, by the Gulf-stream, or the general drift of surface-water. The occurrence of American plants is probably due to vast numbers of migratory birds which come from that continent. These, among them the American golden plover (*Charadrias marmoratus*), probably bring a number of seeds, either attached to their feet or feathers, or temporarily lodged in their digestive tract. A ship laden with grapes had been lately wrecked on the coast. Some of the seed germinated, so that General Lefroy was enabled to obtain a small number of vines for his gardens.

The *Challenger* left the Bermudas on April 21, and arrived at Halifax on May 9, having worked through 44 stations. After a stay of a few days, the ship returned to the Bermudas, 55 stations having been explored. On Thursday June 12, the *Challenger* left the Bermudas *en route* for the Azores. On this voyage some fine specimens of a magnificent barnacle were hauled up, attached to curious nodules, consisting almost entirely of peroxide of manganese, much resembling certain nodules dredged up 700 miles eastward of Sombrero Island. This cirriped,* *Scalpellum regium* (fig. 2), is by far the largest of known living species of the genus, a female specimen having an extreme length of 60 millimetres, of which the "capitulum" was 40 more, and the "peduncle" 20 more in length. The latter was covered with imbricated scales and coarse hairs, and the valves were 14 in number. In two of the specimens there was no trace either of testes or of intermittent organ, but the ovaries were well developed. In nearly all "complemental males" were to be seen, from five to nine in number, attached within the "occludent margins," in a fold of the body-sac quite free from the valve. The male (fig. 3) is very simple, being oval and sac-like, and about 2 inches in length. It has no rudiments of valves, nor is there a trace of a jointed thorax to be seen, even after boiling in caustic potash. The

* See article "Barnacles: their Facts and their Fictions."—POPULAR SCIENCE REVIEW, Oct. 1873.

whole of the posterior two-thirds of the body is filled with sperm sacs.*

With regard to the "Sargasso Sea," the masses of "Gulf" weed which float here are not matted together, but consist of a single layer of the feathery branches of *Sargassum bacciferum*, the vesicles of which plant are encrusted with a beautifully netted white polyzoön. The patches of weed, varying in shade

Fig. 2.

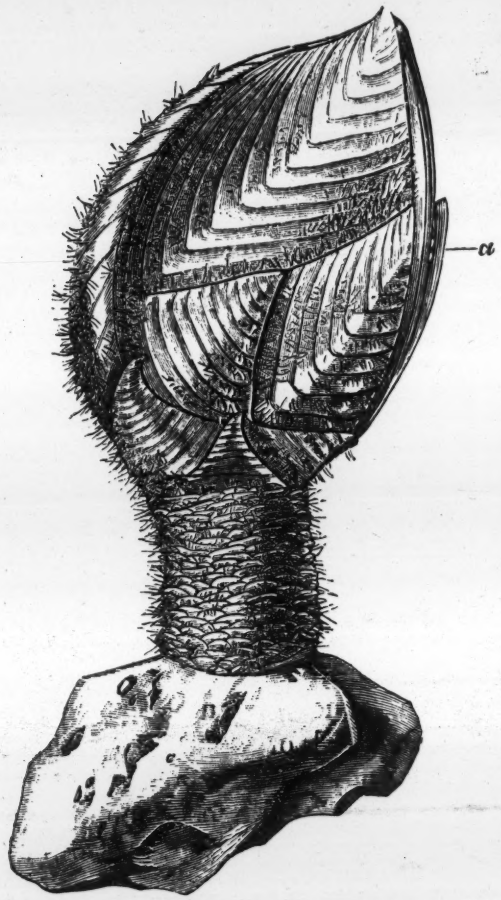
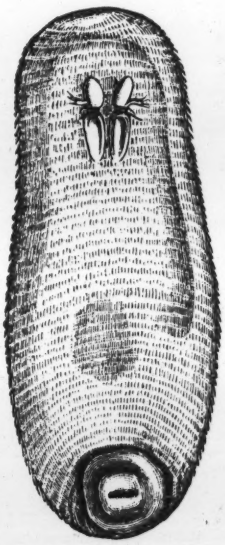


Fig. 3.



from an olive to "a golden tint of olive," form a lovely contrast with the "intense indigo" of the sea between. One of the most perfect examples of protective resemblance is shown by the fauna of the "Gulf" weed, which imitate both in form and colour their habitat, so as effectually to deceive both birds and fishes who might otherwise prey upon them. A little fish —the *Antennarius*—makes nests in the weed, and a small crab which swarms upon the "sargasso" corresponds in degree of colour with whatever part it may chance to inhabit.

* Apropos of this discovery, Mr. Charles Darwin makes, in a long and interesting letter in "Nature," Sept. 25, 1873, some remarks on the males and complemental males of certain cirripedes.

On Friday evening, July 4, the *Challenger* arrived at Porta Delgada, the capital of the island of San Miguel, one of the easternmost of the Azores group. At Furnas, in San Miguel, there are two sets of boiling springs which were explored by the botanist of the expedition for algæ. Connected with one spring there is a basin full of intensely hot water always in ebullition. This had no algæ in it. Some diatoms were found in a hot sulphureous spring, probably derived from a cool spring which mingled with it. Certain *Oscillatoriæ* were also discovered in water so hot as to scald the hand. Unfortunately no exact record of temperature could be made, as no thermometers were at hand which registered sufficiently high.* A peculiar substance of the consistence of Indiarubber was found floating on one of the hot-springs. It burnt like the substance which it counterfeited, and in doing so emitted a similar smell. It resembled, too, as far as Mr. Moseley could remember, a peculiar elastic substance, a specimen of which is in the Kew herbarium among the lichens found upon the shores of an Australian lake. By some it has been held to be a mineral, and on this assumption some specimens are under Professor Maskelyne's care, in the British Museum.

The *Challenger* left the Azores for the Cape de Verde Islands on Wednesday, July 9. The Island of St. Vincent, one of the principal of the group, was visited. It has a flat central tract surrounded by high land, the former part being evidently the bottom of an ancient crater. The abundant plant is *Lavandula rotundifolia*. The tomato (introduced) has run wild everywhere. At the time of the visit there had been no rain for a year, but the island is said to become green after rain as if by magic. The rocks about tide-mark are covered with a band of incrustation composed of calcareous algæ. This incrustation is of several colours, white, pink, or cream-colour.

At St. Paul's Rocks, as at St. Vincent, there is a pinkish incrustation about tide-mark upon the rocks.† A green alga, which is constantly being loosened by the surf from the bottom, and floats upon the surface, is gathered by the "noddies" (*Sterna stolida*) for building their nests, but is not used by the "boobies" (*Sula fusca*). A few bushels of guano are to be found in rock-hollows, which is almost wholly soluble in nitric acid; but no diatoms—which abound in Peruvian guano—are

* For some remarks by Mr. Archer on these algæ, &c., see "Journ. Linn. Soc. Botany," vol. xiv. p. 328.

† Darwin, in his "Naturalist's Voyage," mentions that there is a similar incrustation on the coast of Ascension, resembling certain cryptogamic plants (*Marchantiæ*) often seen on damp walls. Of this he gives a beautiful woodcut.

to be found in the residue. St. Paul's Rocks are detached miniature islands about 1° N. of the equator, and having a longitude of 29° 15′ W., and are 500 miles from the nearest point of South America, lying about midway between that and the African coast. The rock approaches serpentine in structure. Not a trace of land vegetation, not even a lichen, is to be found here. "It is a remarkable fact," says Darwin, "that all the many small islands, lying far from any continent, in the Pacific, Indian, and Atlantic oceans, with the exception of the Seychelles and this little point of rock, are, I believe, composed either of coral or of erupted matter."*

On Aug. 22, St. Vincent's Island was left by the *Challenger* for Bahia, to make her fourth section across the Atlantic. Bahia was reached on Sept. 15, after a successful but stormy voyage. Fernando de Noronha was stopped at, *en route* for Bahia, Sept. 1st and 2nd being spent here. The entire length of the whole chain of islands is about seven geographical miles, the group being situated in 3° 50′ S. lat., and being distant from Cape St. Roque, the nearest point in South America, more than 200 miles. On the main island there is a remarkable column of "phonolite," or clinkstone, more than 1,000 feet high, called "The Peak." The island is volcanic. The Cape gooseberry and the castor-oil plant grow wild here. The plant mentioned by Darwin as covered with fine pink flowers, but without a single leaf, is a euphorbiaceous plant—*Jatropha gossypifolia*, Linn. "Its bare stem," remarks Mr. Moseley, "and branches render it a striking object amongst the green of the creepers when the forest is viewed from the sea." The flora is not very rich in species, and the same plants occur everywhere. There are neither ferns nor mosses, nor liverworts, though moist and shady places are not wanting, and lichens are very scarce. Mr. Darwin observes that the volcanic island of Fernando de Noronha, placed in many respects under nearly similar conditions, is the only other country where he has seen a vegetation at all like that of the Galapagos islands.†

After a stay of a little more than a week at Bahia the *Challenger* left for the Cape of Good Hope, touching at Tristan d'Acunha on the way thither. This group of islands has an area of about sixteen square miles, although stated by Grisebach (*Vegetation der Erde*) to be only two square miles in extent. A plant resembling a chrysanthemum—*Chenopodium tomentosum*—with strong-scented leaves, is used by the inhabitants, a decoction of it, under the name of "tea," being drunk with milk and sugar. It grows abundantly on Inaccessible Island, which is distant about 23 miles from Tristan. Inaccessible Island is

* Darwin's "Naturalist's Voyage." † Ibid.

covered with "tussock" grass (*Spartina arundinacea?*) which forms an enormous penguin "rookery," being so thick as almost to be impenetrable. This grass has a habit, like that of the Falkland Islands (*Dactylis cæspitosa*), of growing to five or six feet, springing in tufts, and forming massive boles or clumps at its base, composed of contorted root-fibres matted together. These are so tough as to require an axe to cut them. The grass thrives best where it is saturated with penguin dung. The close similarity of the three islands of the Tristan group points to a former close connexion. The presence of many plants here may be accounted for by the existence of a Cape Horn current which comes sweeping up to the islands. Part, too, of the Brazilian current, which turns from the coast of South America, brings many seeds, which, however, being tropical, do not germinate. These are known to the settlers as "sea-beans," from the belief that they grow at the bottom of the neighbouring sea. One of these is the bean of a leguminous tree common at Bahia, while another is identical with a seed cast up upon the Bermudas, which, under the same name, is worn as a "curiosity" on watch-chains. The thrush and bunting, the only strictly land birds which inhabit the islands,* feeding, as they do, upon berries, have also assisted in spreading plants from one island of the group to another.

By the time that the month of November had come round the *Challenger* had arrived at Simon's Bay, Cape of Good Hope. After a stay of about six weeks here the journey was resumed southward,† Prince Edward's Island being the first halting-place, though no landing could unfortunately be effected here. After leaving the Cape dredgings were taken a little to the southward at depths of from 100 to 150 fathoms. The animal life was found to be abundant, the fauna being generally like that of the North Atlantic, many species even being identical with those on the coasts of Britain and Norway. From two dredgings between Prince Edward's Island and the Crozets at depths of 1,375 and 1,600 fathoms, it was further demonstrated that here, in the south of the Indian Ocean, we have principally to do with the same deep sea fauna as the Atlantic Ocean presents. From the station between the above two groups an Ostracod was obtained in comparison with which all previous ones are pigmies, its shell having a length of 25 millimetres and a height of 16 millimetres. It is said that one of a

* A coot, according to Darwin ("Naturalist's Voyage"), is also to be found here; from which he deduces that "the waders, after the innumerable web-footed species, are generally the first colonists of small isolated islands."

† I have not succeeded, despite of some pains to ascertain them, in finding out the exact dates of the arrival at and departure from the Cape.

smaller size, *Cytherina Baltica*, exists in the transitional mountain ranges of Gothland.* From this and other similar cases it is suggested that at great depths gigantic forms of genera and families have been preserved which never attain such a size at the surface and in shallow waters.†

At Marion Island a halt was made, and Mr. Moseley had a day at his disposal for collecting plants. The flora was found to be very similar to that of Kerguelen's Island, but was poorer in species.‡ No landing was made at the Crozets. On Jan. 7, 1874, the *Challenger* arrived at Kerguelen's Island, and remained in the neighbourhood till Feb. 1. Here only two plants were found new to the flora, viz. a *Cerastium* and an *Uncinia*. Large collections were made of the famed Kerguelen's Land cabbage (*Pringlea antiscorbutica*, Hooker), and of *Lyallia Kerguelensis*.§ From observations on Kerguelen's Island and elsewhere it is concluded that the higher forms of crustacea are almost entirely absent on the shores of the Antarctic islands, while in deep water here (as has been already witnessed at 300 fathoms) they are present in almost the same abundance as in the tropics. It is also concluded that the characteristic crustacea of the surface-water fauna of the Antarctic islands belong to the *Isopoda* and *Amphipoda*; that is, to forms which carry the ova in pouches up to their full period of development. As the Echinodermata, too, show, as has been observed by Professor Wyville Thomson, an unusual number of species in which the young develope direct in the maternal pouch, conditions must exist which

* Second letter from Dr. Suhm to Professor Siebold, dated Sydney, April 1874. "Siebold and Kölliker's Zeitschr." Bd. xxiv.

† For instance, the President of the Linnæan Society received from Professor Wyville Thomson a drawing of a specimen of a Gymnoblastic Hydroid "of such colossal dimensions that the largest form hitherto known sinks in comparison with it into utter insignificance." It was brought up by the trawl on June 17, 1875, in the North Pacific, from a depth of 2,875 fathoms. The "Hydranth" was 9 inches across from tip to tip of the expanded (non-retractile) tentacles, and the "Hydrocaulus" was 7 ft. 9 in. high! "That the enormous depths," remarks Mr. Allman, "from which this colossal Hydroid has been brought up should favour the development of gigantic representatives of the diminutive forms of shallower zones, and that in the tenants of these sunless regions of the sea we should find colours not less vivid than those of their light-loving relatives, are facts full of significance." See "Nature," vol. xii. p. 555.

‡ "Journ. Linn. Soc. Botany," vol. xlv. p. 387.

§ The fauna and flora of this island have also been described lately by the naturalist attached to the Venus Transit Expedition. See "First Report of the Naturalist attached to the Transit of Venus Expedition to Kerguelen's Island, Dec. 1874," by the Rev. A. E. Eaton. "Proc. Royal Soc." vol. xxiii. p. 351.

are unfavourable to a free-swimming stage of development.* Corinthian Bay, in Yong Island, of the Heard group, was reached on the evening of Feb. 6, but, unfortunately, a change of weather prevented a stay here of more than two hours. "Numerous glaciers come right down to the shore. The vegetation is most scanty, most of the land surface not covered with ice being bare." Only five flowering plants, apparently of the same species as at Kerguelen—among them a much-dwarfed *Pringlea* and one or two mosses, and a liverwort—were found.†

From deep soundings (1,375 to 1,900 fathoms) taken before reaching the Crozets the bottom was found to be composed entirely of *Orbulina* and *Globigerina* dead, and of the same species as those on the surface. Some Coccoliths and Rhabdoliths were also found. Samples of these sea-bottoms were of the purest carbonate of lime yet obtained; and when placed in a bottle and shaken up with water they looked like a quantity of sago. South of Heard Islands the bottom, as shown by soundings at 1,260 fathoms, was quite different, "being one mass of diatoms."

The most southerly station was reached on Feb. 14, being in lat. 65° 42′ S., and long. 79° 49′ E.—just outside of the Antarctic circle, the "threshold" of which is at 66° 32′ S. On Feb. 24, in trying to get under the lee of an iceberg, the *Challenger* was brought by a strong current into collision with it, and had her jib-boom carried away. At this time the ship was really in some danger from the numerous icebergs. On the following day the *Challenger* was within 15 miles of the position of the so-called "Termination Land" laid down on a chart sent by Lieut. Wilks to Capt. Ross. As no signs of it were to be seen it was concluded that its existence was mythical.‡ Laboratory work in the southern latitude was very unpleasant, the microscopes and other instruments being so cold that it was anything but agreeable to handle them, in rooms in which the temperature averaged 25° F. for several days. Dredging, too, was a critical operation, as the gear, becoming stiffened, was liable to part. Berg and floe ice were examined, and were found to contain the usual diatoms. In 48° 18′ S. lat. the fauna was already fully that of warmer zones. The Indo-Australian current therefore extends farther southwards than had hitherto been expected. Indeed, certain surface-animals of the warm Indian current from the N.W. were observed as soon as 50° 15′ lat. S. was reached.§

* Von Willemoes-Suhm.—"Proc. Royal Soc." vol. xxiii. p. 351.

† Moseley. Ibid.

‡ "The Antarctic. A letter from H.M.S. *Challenger*." By Prof. Wyville Thomson, in "Good Words," July 1875. See also a communication "On Dredgings and Deep-sea Soundings in the South Atlantic, in a Letter to Admiral Richards, C.B., F.R.S."—"Proc. Royal Soc." vol. xxii. p. 427.

§ Von Willemoes-Suhm. Ibid.

On March 17 the *Challenger* anchored near Melbourne. The next point reached after Australia was New Zealand. After leaving Port Nicholson, on July 7, the ship proceeded along the eastern coast of New Zealand, and on the evening of the 19th arrived at Tongatabu. On the 22nd the *Challenger* left, and on the 24th anchored off Matuku Island, in the Fiji group. Here a most valuable "take" was made in the shape of a living specimen of the pearly nautilus (*Nautilus pompilius*), which came up in the trawl from the depth of 300 fathoms, It was kept alive in a tub for some time, in order that its habits might be watched. According to Dr. Willemoes-Suhm it is very common in shallow water, and the natives capture it upon the reefs with baskets made up for the purpose. Like the turtle it is a dish, but so choice that the chiefs alone are allowed to indulge in it.* Among the remarkable pelagic animals captured was a naked petropod, in which the "ptera," or wings, were completely absent, their places being supplied by two large conical processes, each of which carried a large black eye at the tip. It is probably the *Pelagia alba*, incompletely described by Quoy and Gaimard. Near the Kermadek Isles the Pyrosomata were so abundant that the sea resembled "a dark carpet covered with large luminous balloons."

On July 28 the *Challenger* arrived at Levuka, the capital of the Fiji Islands, having touched at Kandavu, and on August 3 returned to the latter place, remaining there till the 10th. In this region the impression was confirmed that "while species differ in different localities, and different generic types are from time to time introduced, the general character of the fauna is everywhere very much the same."† Api, one of the least known of the New Hebrides group, was the next halting-place, the *Challenger* arriving at the edge of the reef on August 18. The inhabitants—who were almost entirely naked, of forbidding countenance, and armed with clubs, spears, and poisoned arrows—were mistrustful, and did not encourage intercourse. Large ships scarcely ever touch here, and next to nothing in literature of this island is known. Empty beer bottles, it is said, are the favourite articles of barter with the natives. Raine Island, which was reached on August 31, was the next place of halt. The ship had been accompanied by Mother Carey's chickens ever since leaving Api, but a search for their nests on Raine Island was unsuccessful. This island has been well described by Jukes in his "Voyage of H.M.S. *Fly*." A land crab (*Ocypoda*), like the *Grapsus* on

* Letter to Professor Siebold, dated Cape York, Sept. 1874. Ibid., Bd. xxv.

† Wyville Thomson. "Nature," vol. xi.

the rocks of St. Paul, is abundant in the sand-dunes which are the ramparts of the island, and preys upon the young and eggs of the sea-swallows which swarm here. The same dead turtle was, it is believed, actually seen which Jukes describes as being in a position as though attempting to scale the rocks. The breeding-place of the frigate-bird was found in the middle of the island; but it is not quite certain whether this bird is the *Fregatta aquila* (Finsch and Hartlaub) or *F. minor*. The tropic bird (*Phaëton phœnicurus*) here breeds in holes on the ground, while in the Bermudas its breeding-place is in holes in perpendicular cliffs.

Port Albany, Cape York, was reached on Sept. 1. A number of Australian birds, among them *Megapodius*, were found by Mr. Moseley in "Booby Island," which is now no longer used as a post-office, as the steamers touch at Somerset. The most interesting among the birds of North Australia is the Australian Bird of Paradise (*Ptilornis magnifica*). The landscape, owing to the grey green of the *Eucalyptus*, is monotonous in comparison with the rich green foliage of the Polynesian islands. Termites are very abundant; their mounds being twelve feet high. The queen is not so large as that of the West Indian kind, and did not inhabit any particular royal boudoir, but was to be found here and there in one of the corridors. Of the aborigines only fifteen were alive—"the rest of the members of the stock, who once lived at Cape York, have all been quieted (pacificirt) to death." *

On Sept. 8 the *Challenger* left Somerset and arrived at Dobbo,† an important trading town in the island of Wamma, one of the Aru Islands, on the 16th. From Dobbo the ship proceeded to the Ké group, then to the island of Banda, and afterwards to Amboina, which was reached on October 4. From Amboina the voyage was resumed as far as Ternate, thence into the Celebes sea. On the 26th the *Challenger* proceeded into the Sulu sea, and reached Manila, *viâ* the "Eastern passage," on Nov. 4. A great prize, in the shape of a specimen of the cephalopod *Spirula*, was found in the trawl off the coast of Banda, in the Moluccas, which had evidently passed through the digestive tract of some large fish, probably a *Macrurus*. It is probable that the animal lives in a medium depth of from 300 to 400 fathoms. This is the fourth specimen which has been obtained.‡ An *Amphioxus* was found

* *Vide* a letter from Von Willemoes-Suhm to Professor Siebold (Ibid. Bd. xxvi.), dated Yokohama, Japan, May 1875.

† A picture of this town, as it appears in the trading season, is given in Wallace's "Malay Archipelago," vol. ii.

‡ Von Willemoes-Suhm. Ibid. The history of the other three specimens

in the shallow Aru sea, as well as in the shallow water by Cape York. Commander Chimmo's observations, made in and around the Malay Archipelago, were in the main confirmed. It appears that there is a singular succession of marine basins which are cut off by barriers of varying height from communication with the ocean. From Api to Raine Island the *Challenger* had passed through a breach in the great barrier reef, not far from the entrance of Torres Strait. A sea was then traversed for an extent of 1,400 miles, having a bottom of red clay, and which was included within a broken barrier consisting of Australia to the west, the Louisiade Archipelago, Solomon Islands, and a small part of New Guinea to the north, the New Hebrides to the east, and New Caledonia and a line of reefs connecting this with Australia, to the south. This, the "Melanesian Sea," had no free communication with the outer ocean to a greater depth than 1,300 fathoms. In the Arafura Sea, between Somerset Island and the Aru islands, there is no greater depth than 50 fathoms—the average being from 25 to 30 fathoms; with a bottom of greenish mud, due to the great rivers of New Guinea. The Banda Sea—900 fathoms being the lowest limit of the barrier enclosing it—has for its boundaries Taliabo, Buru, and Ceram on the north, on the east the Aru islands, Timor and Serwatty islands on the south, and Celebes and the shoals of the Flores Seas on the west. The Molucca Passage communicates freely with the outer ocean, and also, by a passage of 700 fathoms depth, with the Celebes Sea. The Sulu Sea was the fourth of the series of marine basins through which the *Challenger* passed in succession from Api to Manila.*

The ship arrived at Hong-Kong from Manila on Nov. 16. Here Captain Nares received a message recalling him home, and giving him the command of the Arctic Expedition, his place being filled by the appointment of Captain Thomson, who was at that time in command of H.M.S. *Modeste*, on the China station. After a thorough refit the *Challenger* again put to sea on Jan. 6, 1875, and passing along the west coast of Luzon, anchored off Manila on Jan. 11. On the 8th, being in the centre of the China Sea, serial temperatures at every 50 fathoms to 400 fathoms, and every 100 fathoms to 1,000 fathoms were taken. At 900 fathoms the temperature was 36°, and this was maintained to the bottom—2,100

are as follows:—1. Sent to England from New Zealand by Mr. Earl, and figured by Mrs. Gray. 2. Sent to France by Péron, and described by De Blainville. 3. Found on the surface of the Sulu Sea, on the voyage of H.M.S. *Samarang*, and described by Professor Owen.

† "Nature," vol. xi. p. 288.

fathoms. This mainly agreed with results obtained by Commander Chimmo, tending to prove that the China Sea is cut off from the Antarctic basin by a submarine rampart, the top of which is between 800 and 900 fathoms beneath the surface.

The news which the *Challenger* brought, that Prince Alfonso had been chosen king by the Spanish people, created but little interest at Manila, the form of Government being indifferent to the officials there so long as they were allowed to retain their posts. On the 11th the ship left Manila, and after passing through the San Bernardino Strait, and the narrows among the islands, anchored off the island of Zebu on the 18th. This was chosen as a halting-place in order that specimens of the lovely *Euplectella* might be obtained. These sponges, called "regarderas" by the Spaniards, seem to be very local, being all obtained from one spot off the island of Mactan, close to Zebu. They are found at a depth of 100 fathoms, and are fished for by the natives by means of a most ingenious kind of dredge made of two slips of bamboo meeting at an angle and armed with large hooks, which is dragged slowly over the mud. The investing layer of sarcode was not so thick as would be expected, scarcely masking the form of the delicate architecture of the spicules, being thus not nearly so spongy as another species of the same genus dredged off the coast of Portugal.* Coal is found in Zebu, and, if labour could be found, would supply the whole Archipelago. On the 25th the volcanic island of Camiguin was visited, the capital of which, Catarman, was entirely destroyed by a volcano which sprung up close to it on May 1, 1871. Since then the earthquakes, which were once frequent, have ceased, and the mountain has increased to a height of 2,000 feet. A sounding was obtained close to the island in 185 fathoms, and the bottom temperature obtained—57°—shows that the volcano did not affect the temperature of the sea. On Feb. 22 the *Challenger*, having, after leaving Zebu, coaled at Malinipa Island, anchored in Humboldt Bay,† New Guinea. "That there is a great future for this vast island," well observes Capt. Davis, "there can be no doubt, situated as it is so near our own colonies in Australia, and producing so much; for that this country, with its accessible sea coast, should remain unproductive, as far as the great family of man is concerned, and entirely closed to commerce, is an anomaly in this nineteenth century that cannot well be understood."‡ No exploration was made of any part of New Guinea, because of the doubtful attitude of the inhabitants.

* "Geographical Magazine," Dec. 1875, p. 359; and a letter in the "Times" of April 30, 1875.

† Visited by Capt. D'Urville, in the *Astrolabe*, in 1827.

‡ "Geographical Magazine," loc. cit.

On March 3 the ship arrived at Admiralty Island, and a bay on the north-west coast was carefully surveyed, and called Nares' Bay, after the late captain. The natives seemed to be superior in every respect to those of Humboldt Bay, and traded with great eagerness.

On March 23, nearly midway between the most southward of the Ladrones and the north-easternmost of the Pellew group, in lat. 11°23′ N. and long. 143°17′ E., the two deepest soundings on record were made, being 4,575 and 4,475 fathoms, the bottom being red clay. The pressure, however, was so great, being five or six tons to the square inch, that three out of four Miller-Casella thermometers succumbed. One, however, fortunately returned in safety, registering a temperature (corrected for pressure) of 34°5, so that at that spot there is a layer of water of that uniform temperature for 3,075 fathoms. As a proof how perpendicular the sinkers descended, particles of the mercury from the broken thermometers were found embedded in the red clay brought up on the tube. A somewhat deeper sounding, viz. of 4,643 and 4,655 fathoms, is said to have been obtained by the United States vessel *Tuscarora* off the east coast of Japan, but the corroborative evidence of a bottom specimen was not obtained. On April 11 the expedition reached Yokohama. On June 16 the *Challenger* left Yokohama, and, after having worked out twenty-four stations in an easterly direction, took a southward course, and reached Honolulu, in the Sandwich group, on July 27. From June 17 up to July 24 the ship was followed by albatrosses, varying in number from fourteen to twenty daily. On July 2 a new species of *Hyalonema* came up in the trawl, which was remarkable for the absence of the zoophyte *Palythoa*, which usually lives as a "commensal" in company with this kind of sponge. The bottom throughout this portion of the cruise consisted of "red clay." On the evening of July 27 the *Challenger* anchored in the harbour of Honolulu.

On the voyage from Hawaii (where the *Challenger* was in August) to Tahiti, the scientific staff of the ship sustained a most severe loss in the death, on Sept. 13, from erysipelas, of Dr. von Willemoes-Suhm. Of him Professor Wyville Thomson says that he was "perfectly certain, had he lived, to have achieved a distinguished position in his profession, and I look upon his untimely death as a serious loss, not only to the expedition in which he took so important a part, but also to the younger generation of scientific men, among whom he was steadily preparing himself to become a leader." *

The last news received from the *Challenger* is to the effect that the ship had safely arrived on Nov. 19 at Valparaiso.

* "Nature," Dec. 2, 1875.

There is, unfortunately, only space for the barest *résumé* of the new facts in zoology and physics established during the voyage. With regard to land-crabs, it had been previously asserted by Bell, contrary to the supposition of Vaughan Thompson, that the young of these crustaceans, like those of *Astacus fluviatilis*, have the same form as their parents on first coming into the world. Now Dr. Suhm, on examining a string of "berry-like pedunculated eggs" of a land-crab belonging to the genus *Cardisoma* (species doubtful), caught in the bay of Porto Praya (Island of San Jago), found some containing young ones which "*were not like their* mother, but Zoëas." The Zoëa of *Cardisoma* leaves the eggs in a somewhat more advanced state than that of *Carcinus mœnas*, representing a middle stage between the larva of the latter which has just left the egg and the one after its first moult (see figs. by Spence Bate in "Phil. Trans." 1858, Pl. xl.). It is probable that the Zoëas leave the mother, and lead a pelægic life until they have undergone all their metamorphoses.* At the Cape of Good Hope Mr. Moseley succeeded in obtaining thirty specimens of *Peripatus capensis*, an animal whose exact position in the zoological scale has been hitherto somewhat doubtful. The most recent information concerning it has been given by Grube in the zoological series of the *Novara* expedition. Nearly all the specimens were found at Wynberg, between Simon's Bay and Cape Town. *Peripatus* seems to be very local in distribution, affecting damp places, feeding on rotten willow-wood, aud being nocturnal in habit. When irritated it shoots out with great suddenness, from papillæ about the mouth, a "viscid tenacious fluid, which forms a meshwork of fine threads." This is not irritant, but as sticky as bird-lime, so that flies are held fast by it. Professor Gegenbaur holds that the position of this animal among the worms is not certain, but that, at any rate, it connects ringed worms with Arthropods and flat worms. With this Mr. Moseley agrees; adding, however, that it is probably an intermediate form linking the ringed and flat worms together with the "tracheata," and may well be placed among Professor Haeckel's "Protracheata."† Mr. Gulliver, when with the Transit of Venus Expedition in 1874, looked carefully for *Peripatus* on Rodriguez Island, but did not find any specimen. On June 15, 1875, halfway between Vries Island, Oosima, and Cape Sagami, there was found adhering to the trawl a specimen of a new family of Nemertines, for which Mr. Moseley proposes the name *Pelagonemertes Rollestoni*. In the flattened form of its body, and in

* "Trans. Linn. Soc." 2nd series. Zoology, p. 46, and Pl. XI. fig. 1.

† "Proc. Royal Soc." vol. xxiii. p. 344, and "Phil. Trans." vol. 164, p. 757, 1874.

having a dendrocœlous intestine, it resembles the Planarins, but in all essential structures it is most distinctly a Nemertine.*

With regard to *Bathybius*, the reputed animal organism, first described by Professor Huxley in 1868,† the organic nature of which has been denied by Dr. Wallich,‡ it seems highly probable that the latter observer is right, for Professor Huxley, *à propos* of a letter from Yeddo addressed to him by Professor Wyville Thomson ("Nature," Aug. 19, 1875), states of Bathybius that it is "seriously suspected that the thing to which I gave that name is little more than sulphate of lime, precipitated in a flocculent state from the sea-water by the strong alcohol in which the specimens of the deep-sea soundings which I examined were preserved." "The strange thing is," writes Professor Thomson, "that this inorganic precipitate is scarcely to be distinguished from precipitated albumen, and it resembles, perhaps even more closely, the proliferous pellicle on the surface of a putrescent infusion (except in the absence of all moving particles), colouring irregularly but very fully with carmine, running into patches with defined edges, and in every way comporting itself like an organic thing." In the same letter it is stated that the "pseudopodia" of *Globigerina*, sought for in vain at the beginning of the cruise, have been at last, and frequently, seen. If a specimen be immediately transferred from the tow-net to some fresh sea-water, and be examined with a high power, the "sarcodic contents of the chambers may be seen to exude gradually through the pores of the shell and spread out until they form a gelatinous fringe or border round the shell, filling up the spaces among the roots of the spines and rising up a little way along their length."

Coccospheres and Rhabdospheres live abundantly on the surface, especially in the warmer seas. If a bucket of water be allowed to stand over night with a few pieces of thread in it, many examples will be found attached. An unfailing supply, too, was found in the stomachs of *Salpæ*. From very numerous observations it may be stated as an axiom, that whenever the depth increases from about 2,200 to 2,600 fathoms the modern chalk formation of the Atlantic and of other oceans passes into a clay—the "red clay"—through an intermediate stage, termed by Professor Wyville Thomson the "grey ooze."

Concerning this red clay, which takes such an important

* "Ann. and Mag. Nat. Hist." 4th series, March and Dec. 1875, and Pl. XI.

† *On some Organisms at Great Depths in the Atlantic*, "Quart. Journ. Micr. Science," Oct. 1868, p. 210.

‡ *On the Vital Functions of the Deep Sea Protozoa*, "Monthly Micr. Journ." Jan. 1869, p. 38; and *On the True Nature of the so-called "Bathybius."* —"Ann. Mag. Nat. Hist." Nov. 1875, p. 122.

share in forming the floor of the ocean, there seems to be no doubt, according to Professor Wyville Thomson, that it "is essentially the insoluble residue, the *ash*, as it were, of the calcareous organisms which form the *Globigerina* ooze;" after the carbonate of lime, which forms about 98 per cent. of this ooze, has been by some means removed. A sample of such ooze was washed by Mr. Buchanan, and subjected to the action of a very dilute acid, and he found that there remained, after the carbonate of lime had been removed, about one per cent. of a reddish mud, consisting of silica, alumina, and red oxide of iron. Now, as all sea-water contains a certain proportion of free carbonic acid, which is greatest at the greatest depths,* it is very probable that this is the agent by which the solution of calcareous matter has been brought about. It is evident, then, that *clay*, which has hitherto been regarded as essentially the product of the disintegration of older rocks, may, under certain circumstances, be an organic formation, like chalk.† Professor Wyville Thomson, having formerly held the contrary, has been at length led to believe, from the results of Mr. Murray's explorations of the surface and sub-surface water, that the *Globigerinæ* pass their whole lives in the superjacent water, only subsiding to the bottom when they are dead. Dr. Carpenter believes that "the truth lies between two extreme views," and that the animals sink to the bottom *whilst yet living*, in consequence of the increasing thickness of their shells, and not only continue to *live* on the sea-bed, but also to *multiply* there.‡

Mr. Buchanan made some observations on sea-water ice, which is known, when melted, to be unfit to drink. Fragments of pack-ice, and also of some ice which had formed in a bucket of sea-water on board, were submitted to various tests, and it was found that the salt is not contained in it only in the form of mechanically enclosed brine, but exists in the solid form, either as a single crystalline substance or as a mixture of ice and salt-crystals. The sea-water ice which had crystallised in hexagonal planes, as common salt does when separating from solutions at temperatures below 0° C., may possibly have some analogy to the isomorphous mixture occurring amongst minerals.§

* There is, moreover, according to Mr. Sorby, an increase of solvent power for carbonate of lime possessed by water under greatly augmented pressure.

† See *Preliminary Notes on the Nature of the Sea Bottom procured by the Soundings of H.M.S. Challenger, during her Cruise in the Southern Sea, in the early part of the year* 1874.—"Proc. Royal Soc." vol. xxiii. pp. 44, *et seq.*

‡ Remarks on the preceding paper.—Ibid. p. 234.

§ *Some Observations on Sea-Water Ice.* "Proc. Royal Soc." vol. xxii. p. 431.

For a most able *résumé* of the fresh facts established by the expedition on which the *Challenger* was despatched the writer is indebted to a lecture delivered by Professor Huxley at the Royal Institution.* The existence of a fine clay in the deeper parts of the Mediterranean had been already known, but no one suspected the existence of deposits of barren clay in the middle of the great calcareo-silicious zone in the open ocean. The dredgings of the *Challenger* have further established that certain ocean-valleys contain thick deposits of finely divided "red clay," the nature of which has been already described, *e. g.* between Teneriffe and St. Thomas, at the depth of about 3,000 feet. If it be, as Professor Wyville Thomson suggests, that the deposits of "red clay" represent remains of myriads of marine organisms, not only silicious and calcareous, but also argillaceous deposits may be formed by long-continued vital agency. Further, it follows that rocks of almost any mineral composition may be indirectly or directly generated by living organisms. It is certain that—

(*a*) Beyond certain depths the calcareous organisms which must fall over the area covered by the ocean disappear, and their place is taken by a fine red clay.

(*b*) When ordinary *Globigerina* ooze has its calcareous matter removed, a residue of fine red clay remains.

Supposing that the earth were covered uniformly with water to a depth of 2,000 fathoms (or about two miles), the merely tidal and current movements already existing would be insufficient to cause any important degradation of the crust, so that there would scarcely be any sedimentary deposits. Let, then, Diatoms, *Foraminifera*, *Radiolaria*, and Sponges be introduced; there would then be formed the silicious Pole-caps, and the intermediate zone, which might accumulate till beds of chalk were formed many thousand feet in thickness. The chalk might next be converted into limestone, and so all traces of its origin would be effaced. Next, let parts of the area be depressed to 1,800 feet and other parts be raised to within 1,000 feet; then, judging by what we now know, the former might be replaced by red clay and the latter by greensand.† The clay might be metamorphosed into shales, slates, &c., and the greensand into minerals into the composition of which silica, alumina, iron, and potash enter; so that the imaginary world would be covered with rocks all due to an organic origin, but of

* *On the Recent Work of the Challenger Expedition, and its Bearings on Geological Problems.* Friday evening, Jan. 29, 1875.—"Proc. Royal Inst." vol. vii. part 5 (No. 62), April 1875.

† A *modern* greensand in course of formation was found by Professor Wyville Thomson in the region of the Agulhas current.

which all traces were obliterated. The application of this hypothesis might reconcile the discrepancy between biological theory and geological fact.

1. There is evidence that the present species of animals and plants have arisen by gradual modification of pre-existing species.

2. There is also evidence that, geologically speaking, this process has extended over a longer period than that of the fossiliferous rocks.

3. Nevertheless, beneath the latter there lies a great thickness of formations almost entirely azoic.

Such researches consequently lend support to the views of those geologists who find the explanation of the past history of the earth in the present operations of Nature—views held half a century ago by Sir H. de la Beche, and developed by Sir C. Lyell, the able supporter of the Uniformitarianism enunciated by Hutton.

Want of space and pressure of time permit of no more than a passing allusion to the interesting controversy which has been going on for several months between Dr. Carpenter and Mr. Croll, of the Scottish Geological Survey, on the subject of "The Crucial Test of the *Challenger*." * Mr. Croll's position seems to be that all the great movements of ocean-water, deep as well as superficial, depend upon the action of winds upon its surface. Though admitting that the Polar water finds its way along the floor of the great ocean basin into the Equatorial area, he affirms that this is merely the reflux of the current which has been driven into the Polar basin by the agency of winds. Dr. Carpenter admits that the *current* movements of *surface*-water are, for the most part, produced by winds, but all these belong to a *horizontal circulation which tends to complete itself*, a surface indraught being produced when a surface outflow is kept up, but that the *deep* movements are the result of a *vertical circulation*, maintained by the continuance of a disturbed equilibrium between Polar and Equatorial columns, occasioned by the surface action of Polar cold and Equatorial heat. It seems, too, that Dr. Carpenter's views as regards a vertical circulation are in accordance with the opinions of Emil Lenz, a physicist who accompanied Kotzebue in his second voyage of circumnavigation in 1823–26. As, however, the controversy does not yet appear to be at an end, and as the subject properly concerns a physicist, any expression of opinion on the part of the writer would be of but little value.

* See "Nature," vol. ix. p. 423, and other papers in the same periodical, as well as a series extending over several numbers of the "Philosophical Magazine."

It is to be hoped that, before the next number of this Review appears, we shall have welcomed back the victors with rejoicing, tempered, however, with sorrow that one out of this brave little band has been left behind in the lone ocean—a congenial resting-place, it may be, seeing that it was the scene of his late labours. "Whom the gods love, die young."

EXPLANATION OF PLATE CXXIX.*

"Es giebt ein vollendetes organisches Leben im unsichtbar kleinen Raume, welches die Grösse des Grossen in der Natur unabsehbar erhebt."—'Ehrenberg, *Die Infusionsthierchen.*" 1838.

FIG. 1. *Globigerina,* with the radiating processes entire. From the *Challenger* soundings. After Pl. I. vol. xxiii. "Proc. Royal Soc." It is evident that when this figure was drawn the investing envelope of sarcode, mentioned by Professor Wyville Thomson in his letter to Professor Huxley ("Nature," Aug. 19, 1875), had not yet been discovered.

FIG. 2. A "Cyatholith," from the Atlantic mud, magnified 1,200 diameters. After fig. 4, *c, i,* Pl. IV. "Quart. Journ. Micr. Sci.," New Series, 1868.

FIG. 3. A "Cyatholith," from the chalk of Sussex, magnified to a similar degree. Ibid. fig. 5, *b, c.*

FIG. 4. A cluster of "Coccospheres," of the *loose* type, about $\frac{1}{760}$th inch in diameter, from the Atlantic mud. Ibid. fig. 7, *d,* and p. 209.

FIGS. 5 and 6. "Rhabdospheres" (Murray), from the *Challenger* soundings. After figs. 3 and 4, Pl. III. vol. xxiii. "Proc. Royal Soc."

FIG. 7. "The new Diatom." Found a little to the North of the Heard Islands. Ibid. fig. 5.

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* The woodcuts have been kindly lent by Messrs. Macmillan & Co.

WATER SUPPLY AND PUBLIC HEALTH.

By W. TOPLEY, F.G.S.,

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IN the year 1868 a Commission was appointed to inquire into the best means of preventing the pollution of rivers, with special reference to the disposal of sewage, to questions relating to water supply, and the public health generally. Five Reports have appeared during the last seven years; these dealt with the pollution of certain selected rivers, the question of water supply being only incidentally referred to. In the sixth and final Report the Commissioners devote their attention exclusively to the "Domestic Water Supply of Great Britain." *

The names of Dr. Frankland and Mr. J. C. Morton are sufficient guarantee for the accuracy of the information given in the Report. But in this complicated question names alone, however eminent, are not sufficient to stamp with unquestioned authority all opinions and inferences; and we do not doubt that some conclusions contained in the Report will be stoutly denied by authorities equally eminent. That the work, so far as *data* are concerned, has been thoroughly done, will be evident from the fact that more than 2,000 analyses of water have been made. These have all been made on a definite plan, and are arranged as systematically as could conveniently be done. The Commissioners state that "water has been followed through the complete cycle of its migrations; it has been caught as it descended from the clouds soon after its condensation from colourless and invisible vapour, collected as it flowed in streams after washing the surfaces upon which it fell, examined after it had penetrated to various depths through

* "Sixth Report of the Commissioners appointed in 1868 to inquire into the Pollution of Rivers." [By Dr. E. Frankland and J. C. Morton.] Folio. Lond. 1874. Pp. xi. 525; Maps and Plans. (Although dated 1874, the Report was not issued till late in 1875.)

different geological strata, and finally it has been investigated after it had become part of the great mass of the ocean."

The Report is accompanied by four maps and several plans and diagrams. One map, by Mr. C. J. Symons, shows the rainfall of the British Isles. Another is geological; this is prepared by Mr. E. Best, chiefly from the maps of the Geological Survey.

In 1867 a Royal Commission was appointed to inquire into the question of water supply, with especial reference to the metropolis; this Commission issued its Report in 1869. The two Commissions thus traversed to a great extent the same grou d, and their Reports will serve as a mine of information on this subject for years to come.

During 1844 and 1845 a series of Reports were issued on the "Health of Towns," which deserve to be better known than they are; but, unfortunately, it is often the fate of "blue books" to be forgotten soon after publication. These Reports are worthy of attention even now for the topographical information which they frequently contain; still more are they worthy of study as denoting the immense advance of sanitary measures during the last thirty years. Bad as matters now are in many large towns, they were infinitely worse then; and sanitary reformers may well take heart at the contrast. Water supply was then one of the most important subjects which engaged the attention of the reporters. Recourse was subsequently often had to neighbouring rivers or streams for a regular supply under efficient control, and for a time all went well. But the towns increased in size, systematic sewerage was introduced, and the rivers were rapidly fouled. And now the problem of how to supply pure water to many overcrowded towns is again awaiting solution.

But, in dealing with this question, it is important to bear in mind that the problem is no longer limited to the larger towns and the great centres of industry. Here there are wealth and public spirit, and sooner or later such places will provide for themselves. But, unless carefully watched, such provision is often made at the expense of smaller towns and villages. One great point in future legislation should be to secure an adequate supply of water for entire districts, especially for those situated within the drainage area from which the supply is drawn.

A study of a good geological map shows that the old village settlements cluster along water-bearing strata; generally they are on or near the edge of porous beds, into which the rain partly sinks as it falls, to be again thrown out as springs at the edge of an impervious bed. There were doubtless other reasons for selecting these sites; land which absorbs water has a dry soil, suited alike for dwellings and arable culture, in days

when draining was unknown. The neighbouring heavier lands were then generally thickly wooded.

Many interesting questions are associated with this inquiry. We can often trace out the earliest settlements of a district along the outcrops of certain strata yielding the best soil and an abundant supply of water; that they are the earliest settlements is evident from an examination of the relations of their parish or township boundaries to the neighbouring hill ranges, and sometimes also from a study of their names.*

In the course of thirteen centuries many changes have been wrought on the physical features of the country. Forests have all but disappeared from the plains and the hill slopes, fens and morasses have been drained. As a consequence partly of these changes many springs which once ran strongly now give but a short and inconstant supply; streams are lessened in flow, and are often nearly dried up in summer. The climate has become drier; but whether the actual amount of rainfall has diminished during this period, and if so how far this change is due to man's influence, are questions at present undecided.

One result of modern agricultural drainage has been to bring the rainwater quickly down into the brooks, and hence the rivers have risen into flood more quickly than before. That the water does descend more quickly after rain than it did some years back, is a matter of common observation amongst anglers and farmers; they also remark that the rivers more rapidly regain their ordinary level than they used to do. These observers, in common with nearly all agricultural authors, explain these facts by the prevalence of drainage. Mr. R. Rawlinson and the Rev. J. C. Clutterbuck, however, deny this;† and the former states that the object of drainage being to carry the water down through the soil, the result must be to retard the flow of water.

But whatever may be the result of under-draining cultivated lands, there can be no doubt of the effect of trenching the upland pastures, moors, and peat bogs, amongst which most of the northern rivers take their rise. Peat acts like a sponge in absorbing the rainfall; the surface of some bogs often rise very considerably when distended by water, and at times when over-strained the surface bursts and considerable damage ensues. But this is only the case with what are termed "flowes" or shaking bogs, which generally occur at low levels; and it rarely happens with the peat bogs of hill districts.

* I have discussed this question in a paper "On the Relation of the Parish Boundaries in the South-East of England to great Physical Features, particularly to the Chalk Escarpment."—"Journ. Anthrop. Inst." vol. iii. p. 32, 1873.)

† See their letters in the "Times" for November 16 and 19, 1875.

These high peat bogs are reservoirs of water, which they collect in winter and yield gradually in summer. They generally lie at too high a level to be cultivated for grass or corn, but they are capable of some improvement as rough upland pasture. This improvement is often secured by deeply trenching the bogs in various directions; the water then drains off, the soil becomes drier and affords feed for sheep. This process is largely going on, and if continued will, in the course of only a few years, make its results seriously felt on the summer and autumn flow of the rivers in the north-east of England. Such results will be less felt, indeed may be comparatively unimportant, in most rivers on the western side of the great central watershed of England; for there the rainfall is much greater, and the periods of drought are shorter. But on the eastern side of the watershed it is simply equivalent to destroying a large number of natural "compensation reservoirs," which at present serve to diminish the winter floods and to augment the summer flow. The additional value conferred on the uninhabited upland moors is but small; the loss to the populous cultivated lowlands is immense.

The late floods have once more made evident the importance of storing the surplus rainfall for summer use. This, with more embankments and fewer weirs, will lessen the floods. Some day probably all this will be done, but at enormous expense. Meanwhile it might be well to see to the preservation of those reservoirs which Nature has herself provided.

A supply of water and the disposal of sewage are two of the most difficult problems of modern times; whilst either, taken alone, would in many cases be comparatively easy. The readiest mode of getting rid of sewage is to pour it into the rivers and streams; but this fouls the natural source of water supply. Pollution of rivers by such means will in time be largely checked; we shall some day discover that sewage is too valuable to be thrown away. But even if the utilisation of sewage should not prove actually profitable, it will be found advantageous to spend public money on this, and thus to prevent the fouling of rivers to the extent now practised and each year increasing. By these and other means the pollution of rivers may be greatly reduced, but it can never be wholly prevented; and it is useless to look for a supply of water for drinking purposes from rivers which traverse manufacturing or populous districts.

"Doctors disagree" in many things of great moment to the public health, but in none is this disagreement more to be regretted than in questions relating to water supply. Complete accord as to opinions and inferences is not to be expected, but we may certainly hope for more agreement as to facts and as to the mode in which these facts are published. Carefully prepared

official Reports on the quality of the metropolitan waters are frequently published by different chemists, but they are made on different plans, and cannot be readily compared with each other.

In old analyses of water the imperial gallon was taken as the standard measure, and the results were given in grains per gallon. As the gallon contains 70,000 grains of water, this is the same as giving parts per 70,000. In 1864 Dr. A. W. Hofmann, then of the Royal School of Mines, was appointed to report on the metropolitan waters to the Registrar-General. He introduced the system of giving the results of analysis in parts per 100,000—a system which has been continued by his successor, Dr. E. Frankland. The analyses for the River Pollution and Water Supply Commissions are given in this form. The imperial gallon is, however, still retained by most chemists; amongst others, by Dr. Letheby, Dr. Voelcker, and Professor Wanklyn.*

This want of agreement is frequently a matter of great inconvenience. As regards the general constituents of water it is less so, because for detailed analyses the standard is generally stated. But where "hardness" alone is spoken of, it is often doubtful which scale is used. This is a point of importance, because the term is in frequent use, and we often read of the hardness of certain waters when no other chemical facts regarding them is stated or perhaps known.

Those who adhere to the gallon as the standard generally describe hardness by what is known as Dr. Clark's scale, which is the same as grains per gallon; a hardness of 7° denoting seven grains of carbonate of lime or magnesia (or their equivalent as sulphates) in a gallon of water.† Dr. Frankland gives hardness in parts per 100,000; so that a hardness of 10° in his analysis is only equal to 7° in Clark's scale. In comparing this and other analytical details there is a simple rule:—to convert parts per 100,000 into grains per gallon (or parts per 70,000), multiply by 7 and divide by 10; to convert grains per gallon into parts per 100,000, multiply by 10 and divide by 7.

Chemists are not unanimous as to the best means to be

* Professor Wanklyn also sometimes states his results in parts per million (or millegrammes per litre). A simple division by 10 converts this into Dr. Frankland's scale of parts per 100,000.

† A further confusion as regards hardness has been introduced by a slight modification of Dr. Clark's method of expressing his result. Even distilled water requires to dissolve some soap before a lather is produced; the quantity required is about one grain to a gallon of water. This by some chemists is added to the result in order to state the actual soap-absorbing power of the water. According to this method, a hardness of 8° is equal to seven grains of carbonate of lime per gallon.

adopted in determining the constituents of organic origin contained in water, and the two Commissions are not at one as to the inferences to be drawn from analyses, even when correctly obtained.

The older analyses of water refer only to "organic matter," without reference to its character; but this really gives us little information of value. One water containing organic matter may be comparatively harmless; whilst another, containing a far smaller quantity, may be highly dangerous. It depends altogether upon the source and nature of the organic matter. This is a very complicated question and cannot be briefly discussed with advantage; but we will note the chief points relied upon by chemists, especially Dr. Frankland. It is necessary to know the precise amount of nitrogen and of carbon (other than that existing as carbonic acid or carbonates); the relative proportion of organic carbon and organic nitrogen gives a clue to the character of the organic matter—whether of vegetable or animal origin; the smaller the absolute amount of nitrogen, and the higher the proportion of carbon to nitrogen, the less the danger of animal matter.

But here a difficulty occurs; during the oxidation of vegetable organic matter the proportion of carbon to nitrogen *lessens*, whilst during the oxidation of animal organic matter the proportion of carbon to nitrogen *increases*. We are thus often thrown back on a knowledge of the source of the water to enable us rightly to interpret the chemical analyses. But, apart from this knowledge, if the absolute amount of organic nitrogen be high, we may reasonably regard the water with suspicion.

Nitrogenous organic matter or "albuminoid ammonia" undergoes putrefaction, and is converted into "free ammonia." The presence of much free ammonia in the water of shallow wells denotes very recent contamination with animal matter. A large proportion of nitrates or nitrites shows that the pollution is more remote, the ammonia having become oxidized into nitrates. But in the case of deep wells the presence of a little ammonia need not denote recent pollution, it may have been formed by the deoxidation of nitrates. But of this at least we may be certain—if the amount of nitrates, nitrites, or ammonia be large, the animal pollution of the water, recent or remote, must have been considerable.

Water from deep wells in the chalk often contains variable proportions (though rarely large) of ammonia and nitrates. One curious result of the careful tabulation of the analyses in the River Pollution Report is this:—The wells sunk through London clay into the chalk yield water of less hardness and with more ammonia than those sunk into the chalk when that rock forms the surface of the ground; nitrates are frequently absent.

Wells on bare chalk give water which always contains nitrates, but from which ammonia is frequently absent. In fact, water from chalk when under London clay appears somewhat to resemble the water from the lowest Tertiary strata, which lie between the chalk and London clay; probably the chalk in such situations is partly fed by water draining downwards from the overlying sands.

Chlorine exists in water chiefly as common salt (chloride of sodium). Water which has been much polluted by sewage always contains this substance in considerable quantity; it is therefore a guide in reading the history of waters. But sewage is not the only source of chlorine. The rain and the air of maritime districts are often charged with sea spray, and during heavy storms salt has thus been carried far inland. After the severe storm of Jan. 1839 salt was found on the trees near Huddersfield, sixty miles from the sea. In Nov. 1703 salt was carried into Sussex, more than ten miles from the coast, making the leaves and branches quite white. Salt will also occur in water after infiltration through strata naturally containing it.

Much discussion has arisen as to the phrase "previous sewage or animal contamination," in which Dr. Frankland sums up the history and quality of various waters; some chemists objecting to the phrase, as sensational or wholly delusive. The meaning of it is this:—An estimate is made of the total amount of combined nitrogen contained in solution in 100,000 parts of average London sewage. This amount varies at different times; in 1869 it was 7·06 parts, in 1857 it was 8·363. For simplicity the number 10 has been assumed. But rain-water always contains nitrogen in these forms; numerous analyses give a mean of ·032 per 100,000 parts as the amount of nitrogen present in rain water as ammonia, nitrates, or nitrites.

"After this number (·032) has been subtracted from the amount of nitrogen, in the forms of nitrates, nitrites, and ammonia, found in 100,000 parts of a potable water, the remainder, if any, represents the nitrogen derived from oxidized animal matters with which the water has been in contact. Thus a sample of water which contains, in the form of nitrates, nitrites, and ammonia, ·326 part of nitrogen in 100,000 parts, has obtained ·326 − ·032 = ·294 part of that nitrogen from animal matters. Now this last amount of combined nitrogen is assumed to be contained in 2,940 parts of average London sewage, and hence such a sample of water is said to exhibit 2,940 parts of previous sewage or animal contamination in 100,000 parts; or in other words, 100,000 lbs. of the water contain the mineral residue of an amount of animal organic matter equal to that found in 2,900 lbs. of average London sewage."*

* River Pollution Commission, Sixth Report, p. 14.

The presence of much nitrogenous organic matter or free ammonia in water is held by all chemists to be a proof of contamination. Dr. Frankland regards the presence of nitrates in the same light. But Dr. Odling, Professor Wanklyn, and others, look upon nitrates as giving no certain information on the matter. It is true that they may be formed by the oxidation of ammonia, this having previously been formed by the fermentation of organic matter; but nitrates exist in deep well-water, to which it is hard to believe that sewage or its derivatives gain access; and they must also be formed in the soil, from the albuminoid parts of plants. On the other hand, living vegetable matter in water abstracts nitrates, and thus the amount of them may be no sufficient measure of its previous pollution.

Organic matters in water are hurtful because of the putrefaction and fermentation which they undergo. But when these changes have reached their final stage, and the organic nitrogen has been wholly converted into nitrates or nitrites, the water is not necessarily unwholesome from its mere chemical contents. The danger is that germs of disease—of typhoid fever and cholera, or the ova of intestinal worms—may remain unchanged, suspended, but not dissolved, in the water. This is especially to be feared in the case of shallow wells, and of streams into which sewage is poured. That typhoid fever and cholera are in this way propagated by drinking water has been proved repeatedly.

The extent to which sewage is oxidised and rendered harmless during its transport by rivers is a question of supreme importance; unfortunately it is also one on which authorities differ. Dr. Letheby believes that if ordinary sewage, such as that of London, "be mixed with twenty times its bulk of the ordinary river water and flows a dozen miles or so, there is not a particle of that sewage to be discovered by any chemical process." Other chemists incline to the same opinion, or at least believe that in most cases sewage is destroyed if carried in this way for long distances.* Dr. Frankland and Mr. Morton devote much attention to this question; and as the result of many analyses of several river waters, including that of the Thames, they believe that "there is no river in the United Kingdom long enough to secure the oxidation and destruction of *any* sewage which may be discharged into it, even at its source." Against these statements should be placed the admission of the Commissioners that the tributaries of the Thames are often more highly polluted than is the river itself at Hampton.

* See the Minutes of Evidence of the Water Supply Commission. The main points bearing on this question are recapitulated in the Commissioners' Report, pp. lxxv–lxxxvii.

As the river and its tributaries receive sewage at many intermediate points, the "previous sewage or animal contamination" at Hampton ought to be considerable; the fact that it is not seems to prove that much of the sewage has been destroyed. The Commissioners explain this apparent anomaly by the *subsidence* of suspended animal matter in quiet parts of the river. Sir B. Brodie and Dr. Lyon Playfair contend that sewage may not be (often certainly is not) *fully* oxidised even after long carriage in river water. Professor Wanklyn states that although urea is rapidly transformed into ammonia and carbonic acid, yet that albumenised matter is very persistent indeed. Mr. Simon puts the matter in the right light in his evidence before the Water Supply Commissioners. He said: "Water into which sewage has been discharged is, in relation to the matter now under consideration, an *experiment on the health of the population*, and I do not think that that experiment ought to be tried."

With regard to the maximum amount of organic matters which may be allowed in drinking water, the following statements will be useful. The River Pollution Commissioners believe that surface or river water should not contain more than 0·2 part of organic carbon, or ·03 part of organic nitrogen, in 100,000 parts. Spring and deep-well water should not contain more than 0·1 part of organic carbon, or ·03 part of organic nitrogen in 100,000 parts.

Professor Wanklyn states that efficiently filtered water may contain from 0·05 to nearly 0·10 parts of albuminoid ammonia per million; when the amount rises to 0·10, or exceeds it, there is defective filtration. "It is a matter of observation that diarrhœa is frequently prevalent in communities which drink such water." Free ammonia exceeding 0·08 part per million generally denotes recent contamination with urine. Much albuminoid ammonia, little free ammonia and little chlorine, denote vegetable contamination; such water is very injurious to health.*

Dr. Frankland and Mr. Morton sum up in the following table their observations on the relative value of waters: †—

Wholesome	1. Spring water (198)	Very palatable	
	2. Deep-well water (157)		
	3. Upland surface water (195)	Moderately palatable	
Suspicious	4. Stored rain water (8—of rain water, 73)		
	5. Surface water from cultivated land	(175)	Palatable
Dangerous	6. River water to which sewage gains access		
	7. Shallow-well water (420)		

* These observations are quoted from "Water Analysis," 3rd ed., 1874, pp. 37, 39.

† Pp. 129 and 425 of Sixth Report. I insert, within parentheses, the number of analyses on which the generalisations are based.

Classified according to softness, the waters stand thus:—

1. Rain water
2. Upland surface water
3. Surface water from cultivated land
4. Polluted river water
5. Spring water
6. Deep-well water
7. Shallow-well water

As regards the water supply of London, the Report just published will greatly strengthen the case of those who are discontented with our present supply—not only as to its quality, modes of distribution and control, but also as to its source. It is not pleasant to think of drinking water mixed with sewage, even although the sewage may enter the river miles away, and the water be most efficiently filtered before delivery. To many who read this Report, what may now be only a matter of taste will become a matter of conviction. The Commissioners unhesitatingly condemn the water supplied from the Thames and the Lea; that supplied by the Kent Waterworks Company to London, from deep wells in the chalk, is good water, its only fault being a high degree of hardness. The New River Company partly derives its supply from springs and wells in the chalk. According to this Report the amount thus obtained is relatively too small to affect the general quality of the water; but absolutely the supply so obtained is considerable, nearly, 12,000,000 gallons per day.

Chalk water is always hard, chiefly from the presence of bicarbonate of lime. Dr. Clark invented a process by which this "temporary hardness" may be removed, which consists in mixing water saturated with lime with the water to be softened. The excess of carbonic acid, which holds the carbonate of lime in solution in the hard water, is then transferred to the free lime, and the whole falls down as insoluble carbonate of lime. Apart from the advantage of softening the water, this process has other recommendations; much organic matter is carried down with the precipitate, and the water will keep better in reservoirs than when in the natural state.

This process has been applied by Mr. Homersham to several waterworks. The water from the deep well at Plumstead was thus softened until the year 1861, when the works were bought by the Kent Company. None of the water now supplied to London is treated in this manner; but the process is used at Aylesbury, Canterbury, Caterham, and Tring, with the following results:—

	Hardness (parts per 100,000).	
	Before softening.	After softening.
Canterbury	26·3	4·9
Caterham	21·2	4·4
Tring	26·3	3·2

The hardness remaining after softening is due to the presence of sulphate of lime or sulphate of magnesia; this is termed "permanent hardness."

The plans which have been suggested for supplying London with water from distant sources, as from Wales and the Lake District, are those most frequently spoken of when dissatisfaction is expressed with regard to the present supply. This is not to be wondered at, for the schemes are bold and complete, the water promised is pure and abundant. Compared with these, the proposals for collecting spring and well water in various parts of the Thames basin, and bringing it by different routes to London, are "patchy" and tame; and yet perhaps in these characters lie their chief recommendation. Is it wise to trust for the supply of the metropolis to a single source, so far distant? Moreover, these distant sources may some day be wanted for the towns in the northern and midland districts.

There seems no necessity for going so far away, as plenty of good water can be obtained within the Thames basin itself. Indeed, no large city is better situated for supplying itself from within its own drainage area; although some—Paris, for instance—are more fortunate as regards deep wells. The average daily supply from the metropolitan companies during 1874 was 116,500,000 gallons, or 34·8 gallons per head; the maximum daily supply was in September, when it averaged 127,600,000 gallons, or 37·5 gallons per head. It is calculated that about one-third of the supply is wasted; one-third goes for trade purposes, flushing sewers, street watering, and fires; only one-third is used for purely domestic purposes.

The Commissioners on Water Supply estimated that it would be desirable to calculate on a future population of 5 millions, with a maximum summer consumption of 200 million gallons, or 40 gallons per head. The present excessive waste can be largely checked by the use of better fittings and more strict control; by such means the consumption in Liverpool has been reduced by Mr. Deacon from 28·89 to 16·47 per head, under constant service. But, to be on the safe side, we will take the figures as they stand. One reason for doing so is the *possibility* that the Thames valley may some day become a busy centre of mining industry. Geologists have long surmised that under the south-east of England there may lie fields of valuable coal measures, at a workable depth.* The Sub-

* Professor Prestwich has fully discussed this question in a former number of this Review (vol. xi. p. 225; 1872). The Metropolitan Board of Works are now putting down a boring at Crossness, which they intend to carry through the Gault. This is in search of water, but its results will

Wealden Boring has as yet thrown no certain light on this question. A decided negative result there will not prove the absence of coal measures under London, and other trials will one day be made in this direction. Wild as this surmise may seem, it is one worth considering as regards this question.

The following table exhibits the amount of spring water available within the Thames basin, including the supply available from wells of the existing companies :—

	Gallons per day.
Springs and wells of the New River Company . . .	12,000,000
Wells of the Kent Waterworks Company	15,000,000
Chalk springs at Grays	10,000,000
„ „ between Lewisham and Gravesend * . .	43,000,000
„ „ above London	30,000,000
Total from the chalk	110,000,000
Lower Greensand district of Leith Hill, Hinahead, &c.† .	20,000,000
Oolitic springs on the N. side of the Thames ‡ . . .	70,000,000
Total . .	200,000,000

These estimates are independent of the Bagshot district, and the lower greensand range from Redhill to Maidstone. The supply might be largely increased by additional wells sunk in the chalk, lower greensand, and oolites. A large quantity of water might be obtained by sinking near the Cotteswolds Hills, through the inferior oolite to the Midford sands; this, however, would probably rob the Severn of its spring water, which now flows out on the western side of the Cotteswolds.

It is thus evident that sufficient pure water can be obtained within a moderate distance of London; sufficient even for the entire future consumption. To bring water from so many sources will certainly be expensive—perhaps as much so as the most costly scheme for far-distant sources. But the expense can be incurred gradually; the nearer sources may be taken first, those further off at later times, as the demand increases.

If the supply for domestic use can be separated from that for general purposes, an enormous saving of good water would

probably be valuable as regards our knowledge of the range of the older rocks. I may here remark that the description which I gave of the Sub-Wealden Boring in a previous number of this Review (vol. xiii. p. 399) requires some modification. A second boring, carried to a depth of 1,820 feet, has proved that the Kimeridge clay extends to 1,750 feet at least.

* Mr. Barlow estimated sixty millions from this source.

† Estimates of the yield of this district vary greatly. I take less than the lowest.

‡ River Pollution Commission, Sixth Report, p. 297. This is the estimated summer yield of only twelve springs.

result; as Thames water could be retained for the latter. The expense attendant upon this change would be very great, but it would probably be less than that required for many of the proposed schemes. Newcastle-on-Tyne and Gateshead are supplied from upland gathering grounds, supplemented when necessary with water pumped from the Tyne. A bill, to be submitted to Parliament during the coming session, provides powers to lay down duplicate mains, with the view of confining the Tyne water to the trade supply.

In the foregoing tabular statement the water is supposed to be obtained in three different ways: from wells, springs, and galleries driven along the water-bearing strata to intercept the subterranean flow of water. It is probable that this last plan will in time be extensively adopted. It was first systematically used by the late Mr. Easton, in supplying Ramsgate by headings driven near the chalk cliff, intercepting the water which before flowed to the sea. Mr. Barlow proposed to collect the chalk-water along the south side of the Thames in a similar way; and Mr. Lucas has recently proposed to use this method extensively for the supply of London. The headings driven from the sides or bottoms of wells to intercept the water-yielding fissures depend upon the same principle; such are now largely adopted. Water is thus *mined for*, along the lines at which it is most likely to occur.

The abstraction of so large an amount of spring water for the supply of London would sensibly diminish the summer flow of the streams. This would have to be restored by large compensation reservoirs in which to store the surplus rainfall. This might also in many cases be largely stored in the great natural underground reservoirs by carrying down shafts through the overlying impervious beds. If sewage can thus be absorbed and got rid of (as it has been on a large scale), the same may be done with surplus rainfall; but this should be done before the water is polluted. Drainage water on the tertiary beds is often turned into the underlying absorbent chalk; the porous beds of the lower greensand and oolites have been used in the same way.

The River Pollution Report refers to many subjects of great interest, in addition to those to which we have too briefly alluded. One of the most important divisions of the volume describes the water supply of provincial towns and villages. This brings out most forcibly how large, in all parts of the country, is the number of shallow wells which yield impure and even dangerous water. Many instances are given in which water fit only for irrigation is constantly used for drinking. A well in the market-place at Deal has a manure valley fully equal to that of average London sewage.

In another part of the Report many analyses are given of shallow wells in London, some of which have a manure value 150 per cent. greater than that of London sewage. Only two of the public wells are considered safe; they are the pump near the south-east entrance to Kensington Gardens, and a well at the Maritime Almshouses, Mile End Old Town. Of thirty-nine shallow public wells which existed within the City in 1866, only four are still open. Dr. S. Saunders has lately recommended that these be closed by order of the City authorities or of the Secretary of State.

This is a matter which has long been a public disgrace. There may be difficulties in the way of providing large towns with a plentiful supply of good water, but there should be none to prevent the closing of public wells which yield slow poison.

At the late Birmingham Sanitary Congress several speakers dwelt emphatically on the evils resulting from shallow wells; in Leeds and Bristol many such wells have been closed by the local authorities.

Rural districts are little if any better off than towns in this respect. Dr. Voelcker states that he analyses a dozen samples of bad water from country places for every one from towns, and that many drinking waters sent to him for analysis are fitted rather for irrigation. Mr. F. Sutton states that out of 429 samples of water taken from wells in the open country, 307 had to be condemned. On inquiry, it invariably occurred that either a dead well or a cesspool existed within a few yards of the well. He thinks it probable that waters suspected to be bad were sent for analysis. We cannot of course suppose that 75 per cent. of country wells are so bad as this.

But all this is an old and now familiar tale. Again and again we read in official reports of how the inhabitants of this or that house, village or town, are poisoned by the foul water of shallow wells. Perhaps in some exceptional cases a little general interest is excited by the statement; but the evils in the particular cases are more or less redressed, and matters go on elsewhere much as they were before. People still speak enthusiastically of the pleasant waters from their favourite wells, perhaps fed by the soakage from neighbouring cesspools or the drainage from adjacent burial-grounds. The connection between the source of pollution and the water drunk is not apparent, and little heed is given to scientific demonstration that such connection exists. And why should heed be given? Is not the water always cool and sparkling, the cesspool out of sight, the graveyard old and long disused? In one case at least these conditions are not all fulfilled, as the following extract will show—sufficiently startling in its simple horror, and needing

no comment or explanation :—"I stood by *the* well at Cawnpore, and I thought how dreadful it was to realise the fact that all the other wells in the surrounding cantonment are in communication with the common grave of our murdered fellow-countrymen and women, 'whose bones lie scattered in that pit,' as the inscription upon their monument declares."*

* A. S. Ormsby. "A New Idea for the Water Supply of Towns, and also for the Troops in India and the Colonies," p. 16. 1867.

THE CRETACEOUS FLORA.

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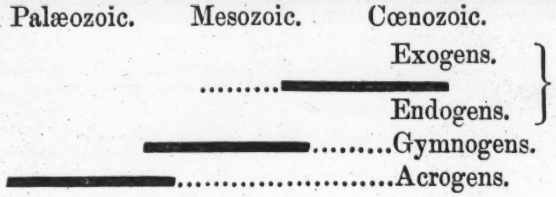
[PLATE CXXX.]

THE conditions under which the various sedimentary strata were accumulated, and the inferences deducible as to the physical geography and climatal characters of the different periods, may be understood not only from the study of the sediments themselves, but more especially from the nature and relations of the remains of the fossil animals and plants imbedded in them. The greater portion of the vast thickness of the stratified formations (estimated at from twelve to sixteen miles, and even more, in thickness) are chiefly due to marine agency, with some intercalated beds of estuarine and fluviatile origin, while others are indicative of old terrestrial surfaces which must have been to some extent more or less contemporaneous with the aqueous deposits then in progress. The evidence of this old land is inferred from the nature of the vegetation and the occurrence of the remains of air-breathing animals associated with it. The general geological belief appears to be—from the nature of the evidence preserved to us in the successively formed fossiliferous rocks—that from the earliest period to the present there has been a gradual increase of the land-surface of the globe. The remains of the animals and plants all point in this direction.

In the Upper Palæozoic period there was a luxuriant land vegetation, some insects, and air-breathing reptiles; in the Mesozoic period many land plants, insects, air-breathing reptiles and warm-blooded mammals, chiefly marsupials, and in the succeeding Tertiary or Cœnozoic period a considerable increase in numbers of the orders and families of animals and plants, both of which have attained their maximum at the present time.

With regard to the development of the vegetable kingdom in time, Mons. Adolphe Brongniart many years since divided it into three great periods corresponding to those above mentioned:

1, the reign of Acrogens, characterised by the abundance of *Equisetaceæ* (horsetails), *Lycopodiaceæ* (clubmosses), *Filices* (ferns); 2, the reign of Gymnogens, characterised by the cycads and conifers; 3, the reign of Angiosperms, characterised by the exogens and endogens. Not that they are special or peculiar to each period, but are the most abundant forms; so that, instead of being a truly consecutive series, they form a more or less parallel one; for in the first period the abundant acrogens are associated with some gymnogens in the form of the coniferæ, in the second period the numerous gymnogens are associated with some angiosperms, which latter increase and constitute the dominant flora of the third period, as shown in the following diagram:—



The earliest well-marked flora is that of the Devonian period, as seen in New Brunswick, Ireland, and some other parts of Europe. In the underlying Silurian (although traces of *Lycopods* are stated to occur) and in still older strata, the *structural* evidence of plants is very scanty; still the occurrence of anthracite, veins of graphite, and beds of iron ore, indicate probably the existence of a former vegetation, whose original characters are so obliterated as to prevent us from determining their real affinity.*

The Mesozoic rocks, characterised by their gymnospermous flora, are divided in ascending order into Triassic, Jurassic, Purbeck-Wealden, and Cretaceous strata, and it may be interesting to inquire what was the nature of the plant-life at the close of the mesozoic period, and to what extent it was related to a preceding, or foreshadowed that of a subsequent period. Comparatively recent discoveries in Europe and America have considerably enlarged our knowledge of this old cretaceous vegetation, from which it appears that, with some forms in common, it is markedly distinct from the lower mesozoic flora, and presents the facies of a tertiary flora, especially in the abundance of dicotyledonous plants, so much so that in some districts the beds containing them were at first considered to be of miocene instead of cretaceous age.

Essentially a marine formation, and consisting of sediments

* Sterry Hunt, "Amer. Jour. of Science," 2nd ser. vol. xxxi. p. 395. C. H. Hitchcock, "Geology of New Hampshire," pp. 508, 509.

of clay, sandstone, and limestone either of mechanical, chemical or organic origin, the Cretaceous rocks are widely spread over the globe, occurring in Europe, Greenland, North and South America, New Zealand, India, and the Pacific Islands. According to locality these rocks vary in mineral aspect, and indicate either deep or shallow water deposits, proximate lines of shore from which drift wood was carried into deeper water, or land-surfaces upon which grew for a long period a sufficiently luxuriant vegetation to form moderate beds of coal, as in New Zealand, Vancouver's Island, and other places. It is the nature of this vegetation we shall attempt to explain, as derived from the various localities where plant remains have been preserved.

In the British area and adjacent parts of France the cretaceous plants are very few. The Lower Greensand or upper Neocomian shows, however, that the land of the Wealden period was not entirely submerged, for with its marine shells are found the Wealden fern (*Lonchopteris Mantelli*), the Wealden Iguanodon, the cycadeous genera *Yatesia* and *Mantellia*, and some cones and stems of coniferæ.

In the overlying gault at Folkestone coniferous fruits have been found, referred to the genus Wellingtonia (*Sequoia*), and others more nearly related to that group of the section *Pinea*, the members of which are now associated with the Wellingtonias in the west of North America, than to any other members of the great genus *Pinus*, which seems to point to the existence of a coniferous vegetation on the high lands of the upper cretaceous period, having a facies similar to that now existing in the mountains on the west of North America, between the thirtieth and fortieth parallels of latitude. No fossil referable to *Sequoia* has hitherto been found in strata older than the gault, and here on the first appearance of the genus we find it associated with pines of the same group, species of which now flourish by its side in the New World.*

In the gault, upper green sand, and white chalk, besides coniferous fruits, fragments of coniferous wood are occasionally found, the latter sometimes having perforations made by a species of *Teredina*.

On the continent of Europe, however, rocks of Cretaceous age have in sundry localities yielded a more or less abundant land flora, distributed at different geological horizons from the lower Neocomian to the Danian or uppermost chalk.

To the Urgonian or middle Neocomian belong the bituminous schists and sphærosiderites of Teschen and Wernsdorf† in the

* Carruthers, "Geol. Mag." vol. viii. p. 540. A. Gray, "Address," 1872, p. 5.

† Schenk, "Die fossilen Pflanzen der Wernsdorfer Schichten in den Nordkarpathen." Palæontographica. Bd. xix.

northern Carpathians, containing numerous vegetable remains. The plastic clays of La Louvière, in Hainaut (Belgium), referred to the gault, contain almost exclusively remains of coniferæ and cycadeæ, and thus their flora differs essentially from that of Aix-la-Chapelle, although it is not far distant, for the latter comprises many dicotyledons but no cycad, and the species and even the genera of coniferæ are different. According to M. Coemans, of all the cretaceous floras known at present, that of La Louvière presents the remarkable peculiarity of not containing any species common to the other floras of the same period. England, Saxony, Silesia, and Moravia, have yielded Cretaceous coniferæ, but they have little or no relation with the Belgian species.*

It is one example of an isolated flora of the period. Besides which the flora of Hainaut seems to afford a series of intermediate types with existing genera: thus *Pinus Corneti* (Coem.) connects *Abies* with *Cedrus*; *P. Andräi*, *Strobus* with *Pinaster*; and *P. Heeri* forms a transition from *Cembra* to *Strobus*.

The upper greensand and lower chalk corresponding to the Cenomanian and Turonian of France, and the lower quadersandstein of Germany and Austria, contain many gymnosperms (coniferæ) and dicotyledons, the latter group here for the first time appearing in any abundance: for the geological position of the Aix-la-Chapelle beds (hereafter noticed) is newer. Strata containing plants referred to the former age occur at Neustadt, in Austria; Niederschöna and Goppeln, in Saxony; Hradek, Kutschlin, Laun, Perutz, Smolnitz, Trziblitz, in Bohemia; Oppeln and Tienfenfurth, in Silesia; and Moletein, in Moravia. Plant-bearing beds of the upper chalk or senonian and upper quadersandstein have been noticed at Blankenburg and Quedlinberg, in the Hartz; at Halden and Sonderhorst, in Westphalia; and it is probable that the Platten-kalk of Westphalia and the sandstone of Klin, near Moscow, containing *Sequoia* and other conifers, belong to this age.

The most interesting locality for fossil Cretaceous plants at present known in Europe is undoubtedly that of Aix-la-Chapelle, where Dr. Debey has noticed more than 400 species, generally well preserved, belonging to all the great divisions of the vegetable kingdom, of which the *Dicotyledonous angiosperms* are the most prominent feature of this old flora.

The Aachenian sands of Aix-la-Chapelle belong, according to MM. Bosquet, Schimper, and Sir C. Lyell, to the upper chalk or senonian.†

* "Mémoires de l'Académie royale de Belgique," tome xxxvi.

† Bosquet, "Foss. Fauna en Flora, Starings Bodem van Nederland," II^de^ Deel. Schimper, "Palæontologie Végétale," tome iii. p. 673. Lyell, "Elements of Geology," 1874, p. 286.

The fossil plants and associated seams of lignite, and of more or less perfect coal, are intercalated with beds of sand and clay of considerable thickness, evidently derived from some neighbouring land, and interstratified with them are occasional bands of limestone with marine shells. "On the whole," says Sir C. Lyell, "the organic remains and the geological position of the strata prove distinctly that in the neighbourhood of Aix-la-Chapelle a gulf of the ancient Cretaceous sea was bounded by land composed of Devonian and carboniferous rocks. These rocks consisted of quartzose and schistose beds, the first of which supplied white sand, and the other argillaceous mud, to a river which entered the sea at this point, carrying down in its turbid waters much drift-wood and the leaves of plants. Occasionally, when the force of the river abated, marine shells of the genera *Trigonia*, *Turritella*, *Pecten*, *Hamites*, &c., established themselves in the same area, and plants allied to *Zostera* and *Fucus* grew on the bottom." *

But the position of the Aachenian sands in Belgium and the north of France, which are at the base of the Cenomanian, has been differently assigned, and were the subject of considerable discussion at the annual meeting of the Geological Society of France at Avesnes (1874).† M. Gosselet refers them to the gault. M. de Lapparent, agreeing with the late M. Dumont, believes they correspond to the Wealden; and MM. Cornet and Briart consider their formation to have commenced at the close of the carboniferous period, and to have continued, with all probability, until the termination of the gault.‡

The flora of Aix-la-Chapelle was essentially terrestrial. A few algæ occur, marine contemporaries of the land vegetation, which comprised numerous ferns, of which three of the genera are at present living: Asplenium, now European, and widely distributed; Lygodium and Gleichenia, not European, the former mostly tropical, and the latter chiefly found in the South of Africa and Australia. The coniferæ were tolerably abundant, including Glyptostrobus, Sequoia, and Araucaria, associated with some new types, as *Cycadopsis*, near to Sequoia, and Moriconia related to the Cupressineæ in resembling *Libocedrus* and *Thuiopsis* of the present flora. Among the Monocotyledons, species of *Pandanus* or screw-pine and other forms occur. Of the dicotyledonous angiosperms, which constitute more than half of the flora, the Proteaceæ—a family now restricted to South Africa, the Cape, and Australia—are very

* "Elements of Geology," 1874, p. 286.

† "Bulletin Soc. Géol. de France," 1875.

‡ "L'Aachenien et la limite entre le Jurassique et le Crétacé dans l'Aisne et les Ardennes," par M. Ch. Barrois. Bull. Géol. Soc. de France, 3 ser., tome iii. p. 257.

predominant. Besides extinct genera there are others, considered to belong to living forms, as Adenanthus, Banksia, Dryandra, Grevillea, Hakea, and Persoonia. Associated with these Proteaceæ are the fig, bog-myrtle, willow, poplar, the oak, beech and dryophyllum, a cupuliferous genus allied to the chestnut-oak, also Credneria, and cissites related to the Ampelideæ, together with some forms of the Myrtaceæ, as *Eucalyptus*, &c.*

The eastern continent, like the western, affords equally interesting facts as regards the old land surfaces of the Cretaceous period. In Spitzbergen and Greenland, under latitude 70° N.—where now almost perpetual ice and snow reign, with the disappearance of the snow there suddenly springs forth a herbaceous vegetation, rushing into leaf and flower, to be speedily destroyed by the return of the winter's frost after a very short summer—there is evidence of a forest vegetation at the Cretaceous and Miocene periods, indicative of a temperate or even subtropical climate, thus showing that great physical and cosmical changes have taken place in the Arctic regions, and inferring at those periods a different distribution of land and of warm oceanic currents from that which obtains at present. The researches of Professor Nordenskiöld, in connection with the late Swedish expeditions, and the subsequent determinations of Professor Heer, have thrown considerable light on the ancient floras and climates of the Arctic regions.† The Cretaceous strata of Greenland, according to Professor Heer, belong to two different stages, and contain different floras. The lowest division is met with at Kome or Kook, and other places on the north side of the Noursoak Peninsula in North-western Greenland. These strata, considered to be of middle Neocomian age (Urgonian), contain some plants which resemble those of Wernsdorf in the Carpathians. About seventy-five species are described, belonging to fifteen families; more than one-half are Cryptogams, chiefly of the fern tribe, among which the species of Gleichenia play the chief part, a genus which still flourishes in the vicinity of the tropics and warmer portions of the temperate zone; but *Sphenopteris* and *Pecopteris* are not rare. The other plants are chiefly gymnosperms—the Coniferæ—some of which are nearly related to forms still existing in Florida, Japan,

* Debey, H. M. "Uebersicht der urweltlichen Pflanzen des Kreidegebirges, überhaupt und der Aachener Kreideschichten insbesondere."—Rhein. u. Westphal. Verhand. 1848, pp. 113–142.

Debey, H. M. und Ettingshausen. "Die urweltlichen Thallophyten des Kreidegebirges von Aachen und Maestricht."—Wien. Denkschr. Akad. Wiss, xvi. 1859, pp. 131–214. "Die urweltlichen Acrobryen."—Ibid. xvii. 1859, pp. 183–248.

† "Flora fossilis Arctica."—Zurich, 1868, 1875.

and California (*Sequoia*), and Cycadeæ, most of which are referable to the genus *Zamia*, species of which are now met with within the tropics. A leaf was also found. From the general nature of the flora Heer considers that, in the early part of the Cretaceous period, the climate of the now ice-covered Greenland was somewhat like that which now prevails in Egypt and the Canary Islands.

The upper Cretaceous beds, referred to the Cenomanian or Turonian, occur at Atane and on the shore below Atanekerdluk, on the south side of the Noursoak Peninsula. The number of species is nearly equal to that found in the lower Cretaceous at Kome, but their type is almost totally different, although five species are common, but they are quite unlike the Greenland Miocene plants. *Sequoia*, again, predominates among the conifers, and with it a *Thuites* and *Salisburea* were found; cycads are rare. Among the ferns there are still some *Gleicheniæ*, but other forms, as *Marattiaceæ* and *Dictyophyllum*, have disappeared. The predominant forms are dicotyledons; there are three species of poplar, one fig, one *Myrica*, a *Sassafras*, a *Credneria*, some *Proteoides* and *Leguminosites*, and two *Magnoliæ*.*

Professor Nordenskjöld, in speaking of this Cretaceous flora, in a lecture to the Royal Swedish Academy (1875), says, "Among the ferns, cycadeæ, and coniferæ of Noursoak Peninsula (lower Cretaceous) were found a few impressions of a species of poplar, *Populus primæva*, which formed the only and at the same time the oldest known representative of the forest vegetation now prevailing in the temperate zone. Nevertheless, the vegetation of the Arctic tracts was already during the Cretaceous period undergoing a complete transformation. Evidence of this has been obtained from the same locality, Atanekerdluk, on the south side of the Noursoak Peninsula. Here impressions of plants may be discovered belonging to the Cretaceous formation, not to the lower but the upper portion of it. The vegetation is here quite different. The ferns and cycadeæ have disappeared, and in their place we find deciduous trees and other dicotyledons in astonishing variety of forms, among which a species of fig may be mentioned, of which not only the leaves but also the fruit have been obtained in a fossil state; and species of Magnolia, Sassafras, Proteoides, &c. The climate that then prevailed over the whole globe was therefore still warm and luxuriant, even if, at least in the Arctic regions, considerably modified from what it formerly had been, inasmuch as the flowerless vegetation (which was now beginning to die out)—as far as we can judge from its present representatives, the ferns—required a warm humid climate;

* See R. H. Scott, "Geol. Mag." Feb. 1872, p. 71.

whereas the new forms, with their luxuriant flowers, which now began to characterise the vegetable world, required, in order to develope all the grandeur of their colours, a clear and sunny sky. The disappearance of sundry tropical and sub-tropical forms, that are met with in the older Cretaceous strata, has led Heer to the conclusion that difference of climate at different latitudes was now beginning to show itself; and he calls attention to the circumstance that this takes place synchronously with the development of the dicotyledonous plants in greater variety." *

The Cretaceous character of the strata containing coal and lignite at Vancouver's Island and adjacent district was some years since noticed by Dr. Newberry, and these and their extensive development along the Pacific coast have been described by Dr. Hector.

At Nanaino—where the coal has been largely worked, as on Newcastle Island—there are two seams, the first of which is about six feet in thickness, with sometimes a floor of fire-clay, but more generally of sandstone; and the roof, consisting of the fine conglomerate bed, about sixty feet thick, on which rests the Douglas seam, with an average thickness of about four feet.†

The coals and fossil plants of Vancouver's Island were considered at one time to be of Tertiary age, but this identification appears to have been made upon insufficient evidence. Among the fossil plants there is one, the *Sequoia Reichenbachi*, which is numerous in localities in the Cretaceous of Europe and in the Arctic regions. Interstratified with and overlying the beds of coal at Nanaino are strata containing great numbers of well-marked Cretaceous mollusks—*Ammonites*, *Baculites*, *Inoceramus*, &c.‡

The most abundant North American Cretaceous flora is that of the Western Territories, collected from beds known as the Dakota group, by the labours of Dr. Newberry, and the geological survey under Dr. Hayden, and recently described by Professor Lesquereux.§

The Dakota group lies at the base of the Cretaceous series, and, with the associated Fort Benton group, is equivalent to the Cenomanian and Turonian of Europe; overlying these are many hundred feet of strata, destitute of plants, referred to the upper chalk or Senonian, and above these are the remarkable lignitic beds or "Transition Series" of Dr. Hayden, which

* "Geol. Mag." Nov. 1875, p. 529.

† Hector, J. "Quart. Journ. Geol. Soc." vol. xvii. p. 433. See also Newberry, "Proceed. Boston Nat. Hist. Soc." 1863.

‡ J. S. Newberry, "American Journ. Science and Arts," April 1874.

§ "The Cretaceous Flora." Washington, 1874.

from their fauna are considered by Dr. Cope to bridge over what is generally considered one of the greatest gaps in geological chronology. The Dakota group, corresponding to the Upper Cretaceous of Europe, like the beds of Aix-la-Chapelle and the Aachenian sands of Belgium and others of Bohemia, are immediately superposed on the Palæozoic rocks, thus showing a great physical break, or lapse of unrepresented time, during which in other areas thick marine sediments were accumulating.

The Dakota group has been recognised to have a vast range along the flanks of the various mountain-ranges from north to south, extending from North Texas to the northern limits of the State of Minnesota, is presumed to extend into British America, and as the fossil leaves of the Upper Cretaceous of Greenland represent some genera and perhaps species of the Dakota group, it would seem that this formation has been continuous from the Gulf of Mexico to the Arctic lands, Greenland, &c., over 35° of latitude. The fossils have been chiefly found on the plains in the eastern portions of Kansas and Nebraska.

About 130 species of plants have been determined, including six ferns, nine coniferæ (Sequoia, &c.), one cycad, three monocotyledons; the remainder are dicotyledons, and represent species referable to the genera *Liquidambar*, *Populus*, *Salix*, *Betula*, *Myrica*, *Celtis*, *Quercus*, *Ficus*, *Platanus*, *Laurus*, *Sassafras*, *Cinnamomum*, of the Apetaleæ; *Diospiros* of the Gamopetaleæ; *Arolia*, *Magnolia*, *Liriodendron*, *Negundo* or *Acer*, *Paliurus*, *Rhus* or *Juglans*, and *Prunus* of the Polypetaleæ; or, merely considering the affinities to our present flora, seventeen genera are those to which belong the species of our trees and shrubs which have the more general and the widest range of distribution. Indeed, all our essential or arborescent types are there, except those which are marked by serrate or doubly serrate leaves. This general facies of the leaves of the Dakota group, viz. integrity of borders and coriaceous consistence of leaves, is peculiar.

The borders, if not perfectly entire, are merely undulate or obtusely lobed; to this there is scarcely an exception. This mode of division of the borders of leaves is very rare in species of our present times, except perhaps in some species of poplars.*

Considered as a whole, most of the types of the Dakota group, related to those of our present flora, represent a moderate climate, like the one prevailing now between 30° and 45° of North latitude. Professor Heer has the same opinion in regard to the climate of the upper Cretaceous epoch of Greenland, as indicated by its flora.†

* See Lesquereux, "The Cretaceous Flora," p. 128. † Ibid. p. 39.

With regard to the conditions of deposition, Professor Lesquereux remarks, that the character of the leaves found in the Dakota group, and their analogy with species of our time, seem at first to refer them to a dry land flora; this is, however, not positively the case. The most abundant representative of the Cretaceous flora, the Sassafras, is remarkably similar to the present *Sassafras officinalis*, which inhabits every kind of ground and station, from the dry hills of Ohio to the low swamps of Arkansas. The numerous leaves of Laurus are comparable to those of *L. caroliniana*, a shore plant; as are also the *Platanus*, *Magnolia*, *Populus*, *Salix*, *Menispermites*; the essential types of the Dakota group being, therefore, those of low islands or low shores, rather than hills or dry land. Professor Mudge says the characteristic of the local deposits of this group in the State of Kansas indicate that the forests were on small islands scattered over the Cretaceous ocean.*

In Cumberland and Nelson provinces, New Zealand, rocks referable to the Cretaceous age by their fossils overlie valuable coal-seams, locally altered into anthracite, and associated with the shales and sandstones is a rich dicotyledonous flora, both angiosperms and gymnosperms, as the Myrtaceæ, Fagus, Coprosma, Dammara, Phyllocladus, Podocarpus, Dacrydium, &c., many of the genera still existing in the New Zealand flora. There is one locality at Pakawu, where the genera Pecopteris and Tæniopteris are clearly associated with the dicotyledonous plants, the species however being different from those representing the same genera in an underlying sandstone, which is undoubtedly of Jurassic age, and which species are mostly identical with those found in the Rahmajal series of India.

Overlying the coal-bearing rocks are a series of conglomerates, sandstones, calcareous marls and chalk, with flints in some localities more or less developed, and there is evidence in the upper part of this series of fossils with an Eocene facies, succeeded by lignite beds indicating a land surface.†

The Cretaceous period may be divided into two distinct periods according to the nature of its terrestrial vegetation, and these somewhat agree with the ordinary geological divisions; including the Wealden, Neocomian, and Gault in the lower; and upper green sand, lower, middle, and upper chalk in the upper division.

M. Schimper has divided the Cretaceous flora as follows:—Etage Intérieur (Neocomien, Urgonien), Etage Moyen et Supérieur (Aptien to Danien).

The general Cretaceous flora includes: Thallogens, as Algæ; Acrogens, as ferns and equisetum; Gymnogens, as conifers

* "Trans. Kansas State Board of Agriculture," p. 295.

† Dr. Hector, "Trans. New Zealand Institute," vols. ii. and vi.

and cycads, a few monocotyledons, as palms; dicotyledons, as the ordinary forest trees; but it is the different distribution of these classes that forms the marked feature of the two divisions. In the lower group, the gymnogens and cryptogams are abundant; in the upper, the dicotyledons are most numerous, with some conifers and ferns. This distribution has some relation to the floras preceding and succeeding the Cretaceous period. Thus the preceding Jurassic flora is composed of *ferns*, a few Equisetaceæ, some Coniferæ, and a great abundance of Cycadeæ. Three-fourths of all the fossil *Zamiæ* and half of the Cycadeæ, known from all the geological formations, are Jurassic. In the lower Cretaceous of Wernsdorf and Greenland, especially the latter, Heer finds a marked proportion of this family which is scarcely represented in the upper. Of the *Coniferæ* the lower Cretaceous rocks (Gault) contain the earliest known representative of *Sequoia*; this genus is interesting, not only as a persistent type ranging from the Cretaceous to the present, but from its wide distribution at former geological periods, *i.e.* the upper Cretaceous and Miocene, and being now represented by two species only (the Redwoods), and those restricted to a comparative limited area in North America, the *S. gigantea* (Mammoth tree or Wellingtonia) to the western flank of the Sierra Nevada, and *S. sempervirens* along the coast range from the bay of Monterey to the frontiers of Oregon.* The absence of dicotyledons, the presence of a few monocotyledons, and the abundance of the Cycadeæ. approximate the lower Cretaceous to the previous Jurassic flora.

On the other hand, the Upper Cretaceous presents a distinct assemblage, and affords the first well-marked proof of the introduction on the earth of a vegetation allied to our fruit and forest trees.† Among the ferns are the living genera Gleichenia, Lygodium, Asplenium, together with the earlier forms Sphenopteris and Pecopteris; scarcely any Zamiæ, but some Coniferæ, as Abietites, Phyllocladus (?) Sequoia, and its near relative Glyptostrobus, now living in China. Of the numerous genera of dicotyledons are the fig, willow, poplar, beech, oak, plane, sweet-gum-tree (Liquidambar), sassafras (abundant in the Dakota group), Magnolia, Liriodendron (tulip-tree), some Proteaceæ, and other living and extinct genera, including *Credneria*, many of them having at present a very different geographical distribution. Among others, the *Magnolia* and *Liriodendron* belong to North America by origin, succession, and presence. Of the eight species

* See Lesquereux, "Cretaceous Flora," p. 116; and Professor A. Gray, "Address to the American Association at Dubueque, Iowa," Aug. 1872.

† Lesquereux remarks that "the essential types of our actual flora are marked in the Cretaceous period, and have come to us after passing, without notable changes, through the Tertiary formations of our continent."

of true Magnolia now known to botanists, seven belong to the western slope of the temperate zone of North America. *Liriodendron*, the Tulip-tree, has in its characters, its distribution, and its life, a great degree of affinity with *Magnolia*; the American species is the only one now known in the vegetable world, and its habitat is strictly limited to America. Either considered in its whole or its separate characters, the tulip-tree is a constant subject of admiration and wonder. It could be named, not the king—it is not strong enough for that—but the queen of our forests, if the *Magnolia* was not there with it to dispute the prize of perfection by the still grander majesty of its stature, the larger size of its foliage, the elegance and perfume of its flowers. Our sense of admiration for these noble trees is heightened still by the dignity of their ancient origin.*

The upper Cretaceous rocks, therefore, by their numerous forms of dicotyledons strongly foreshadow the Tertiary and succeeding floras. As partly bearing on this point, Professor Lesquereux states, as regards the Western Territories, "In ascending from the lower lignitic measures, where the essential types of the Cretaceous flora (the Dakota group) have no representatives, we see these Cretaceous types re-appearing, a few in the Upper Eocene, more in the Carbon group above, still more in the Upper Tertiary, following thus an increasing degree of predominance, culminating, it seems, at the present time, in the flora of the eastern slope of the North American continent."†

A character of the Cretaceous floras is their apparent want of homogeneity; even when probably synchronous, they are so diversified, when compared to each other, as to appear not to belong to the same epoch and the same country. On this point MM. Saporta and Marion remark, in alluding to the localities which have been carefully studied, "What point of analytical connection can be established between Niederschœna in Saxony, Moletin in Moravia, Quedlinburg and Blankenburg in the Hartz, Halden in Westphalia, the sands of Aix, the Senonian of Bausset, the Santonien of Fuveau, and the North American Cretaceous of Nebraska?"‡ Professor Lesquereux also shows that the Dakota flora, with scarcely any forms referable to species known from coeval formations of Europe, presents in its whole a remarkable and as yet unexplained case of isolation.

Contemporary, therefore, with the extensive marine deposits of this period—some of a peculiar nature, great thickness, and uniform character, as the white chalk, indicating deep-sea conditions—there were evidently land surfaces either distributed as islands in the cretaceous ocean, or forming more or less low

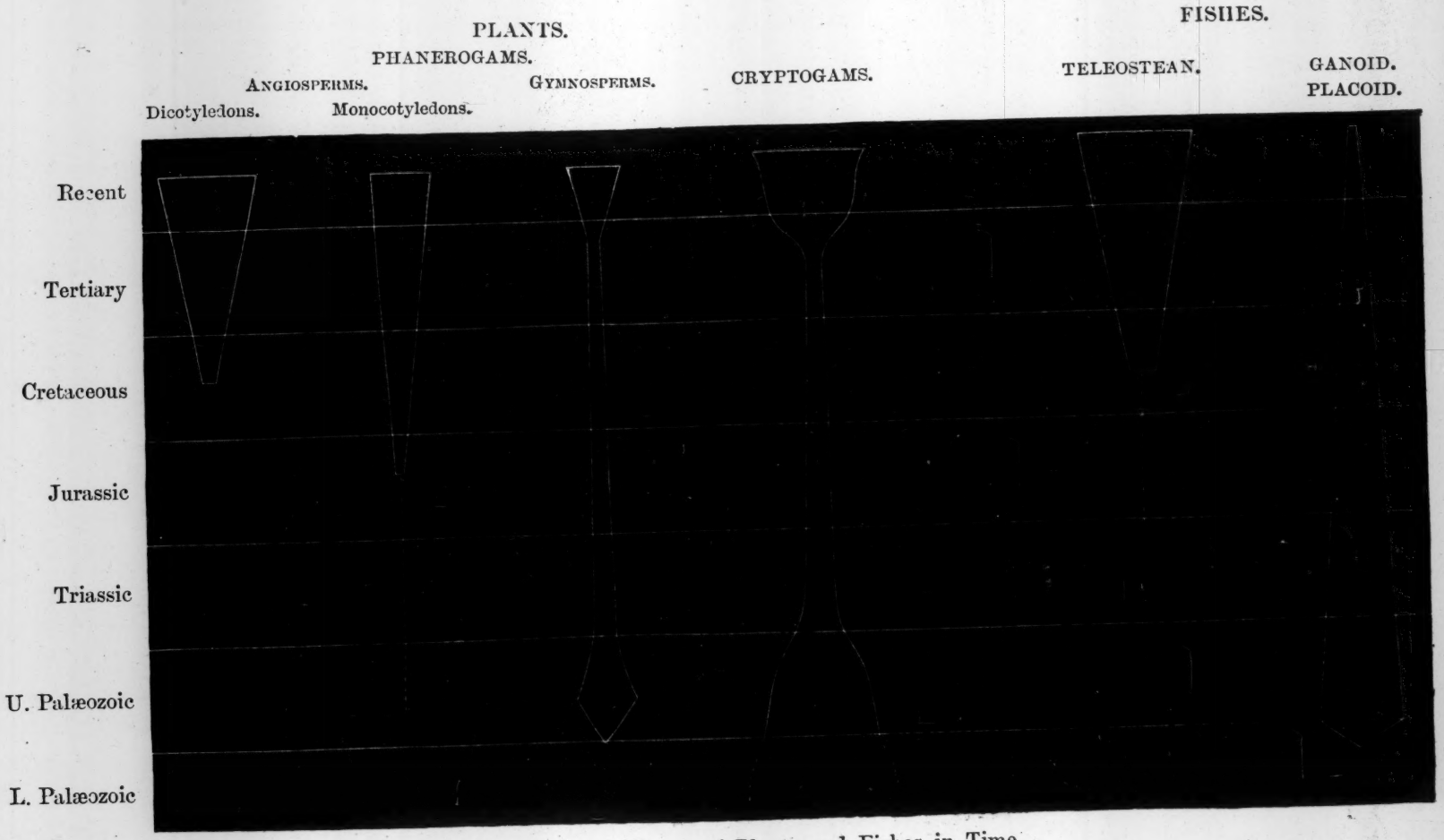
* Lesquereux, "Cretaceous Flora," p. 121. † Ibid. p. 117.

‡ "Essai sur l'état de la végétation à l'époque de marnes heersiennés de Gelinden." Par Count Saporta et Dr. F. A. Marion. P. 14.

shores bordering the same, upon which grew a vegetation varying in character, and sometimes localized, according to climatal conditions; in some places sufficiently luxuriant to become the source of future beds of coal; in other places, to be carried by rivers or other means and imbedded with the marine remains of the adjacent sea. This vegetation was not, however, of uniform character throughout the Cretaceous period, but became modified and varied in the various stages, and with a marked difference in the lower and upper periods. In the lower, with the incoming of a new marine fauna, the plant-life resembled that of the previous Jurassic age; whilst in the upper, with a comparative similar aspectal fauna, the cotemporary vegetation was different from that of the lower Cretaceous period, and presented a land facies resembling that characteristic of the subsequent Tertiary period, in which the forms of the cotemporary marine life were entirely changed.

In recapitulating the evidence derived from our present knowledge of the distribution and character of the Cretaceous flora, it appears—1. That in the different localities from which the plants have been described, while the floras have some points in common, they are more or less localised in character, probably in consequence of different physical and climatal conditions. 2. That the Upper Cretaceous flora differs considerably from the Lower, inasmuch as the latter, by the predominance of the gymnosperms, is related to and continuous with the previous Wealden and Jurassic flora; while the former, containing a few of the older forms, is marked by the abundance of the dicotyledons, thus foreshadowing the subsequent Tertiary flora. 3. That while in some areas the Cretaceous flora yields generic forms, which are now represented and living in the same area—as for example in New Zealand, Europe, and America—in other places, as in Greenland, there are no such living representatives; and again, some genera, as *Sequoia*, which were widely distributed during the Cretaceous period, are now restricted to a single locality. 4. That the appearance of a phænogamous flora in the upper Cretaceous rocks affords a parallel to the occurrence in the same formation of the teleostian fishes, both of which classes not only increase in the subsequent Tertiary period, but are the dominant forms at the present day, as shown in the accompanying Pl. CXXX.

These occurrences may indicate either distinct creations, adapted to the then existing inorganic conditions, or, when our knowledge of the earlier forms is more extended, it may be shown to have resulted by modification during long periods of time of previous generalised or ancestral types, of which there is some evidence in the underlying Jurassic and still older formations.



Range of Plants and Fishes in Time.

THE "INFLEXIBLE" AND HER ARMAMENT.

By A. HILLIARD ATTERIDGE.

[PLATE CXXXI.]

THE old type of man-of-war is now fast becoming a thing of the past. The splendid three-deckers and swift-sailing frigates that carried our flag to victory in the days of Jarvis and Nelson, or that only twenty years ago engaged the sea-forts of Sebastopol and blockaded the Baltic shores of Russia, will soon be as obsolete as the triremes of ancient Rome and the "tall galleons" of the times of the Armada. Already they have disappeared from the line of battle, and are relegated to the humble position of guardships at our home ports or cruisers on distant stations, where their most serious enterprises are the bombardment of a village or the capture of a slaver. One by one they are condemned and broken up, and no new ships are laid down to replace them; and already we can anticipate the time when perhaps the sole representative of the grand old floating fortresses, that once formed our great unarmoured fleet, will be Nelson's ship, the *Victory*, lying at her moorings in Portsmouth harbour like some war-worn veteran of Greenwich or Chelsea whose fighting days are over, and who is spending his old age in honourable retirement.

The modern man of war is much more than an armed steamer. She is herself a great engine of destruction, provided with huge guns, clad in heavy armour, driven by powerful engines, and able to send an adversary to the bottom by one successful blow of her enormous bow. Year by year the thickness of armour and the weight of naval artillery go on increasing together: mechanical appliances have more and more replaced manual labour both in the dockyard and on shipboard; and at the same time the form of the ships themselves has been carefully adapted to the work they have to do and the conditions under which they must act. Our first great ironclad, the *Warrior*, was only an ordinary war-steamer very incompletely protected with armour,

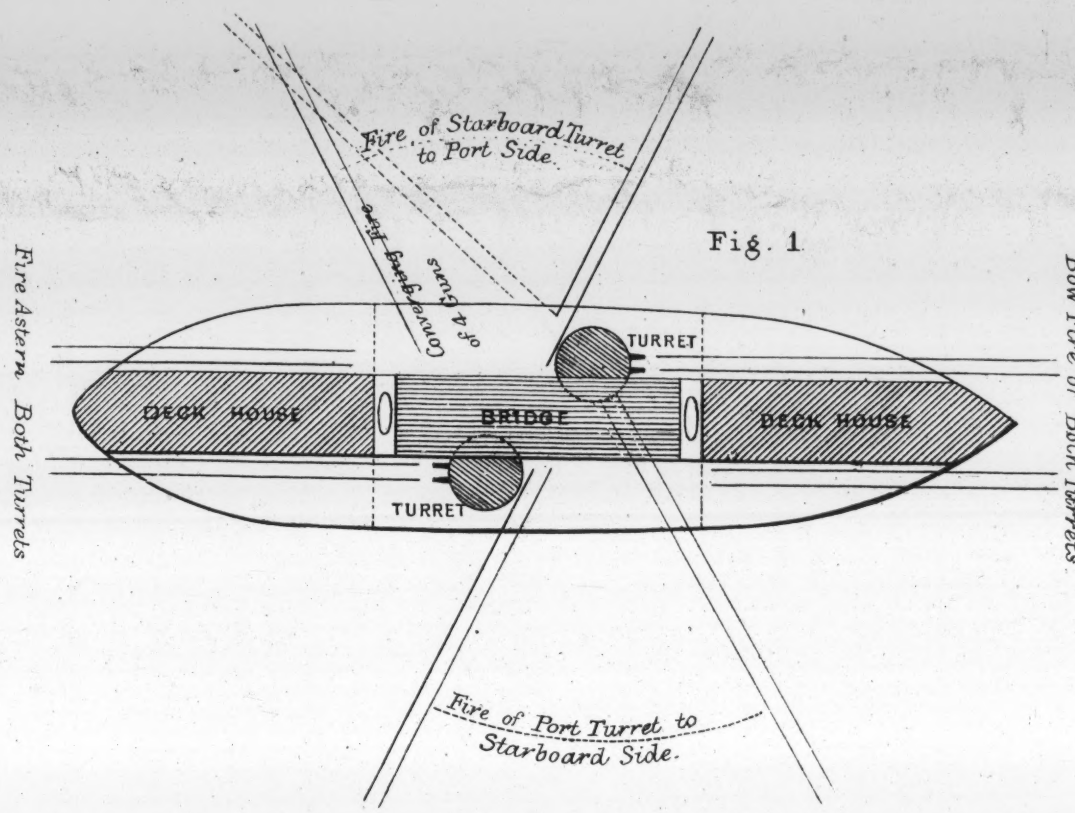


Fig. 1

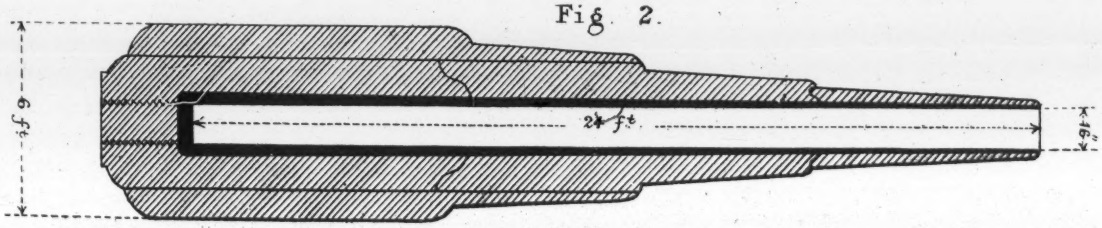


Fig. 2.

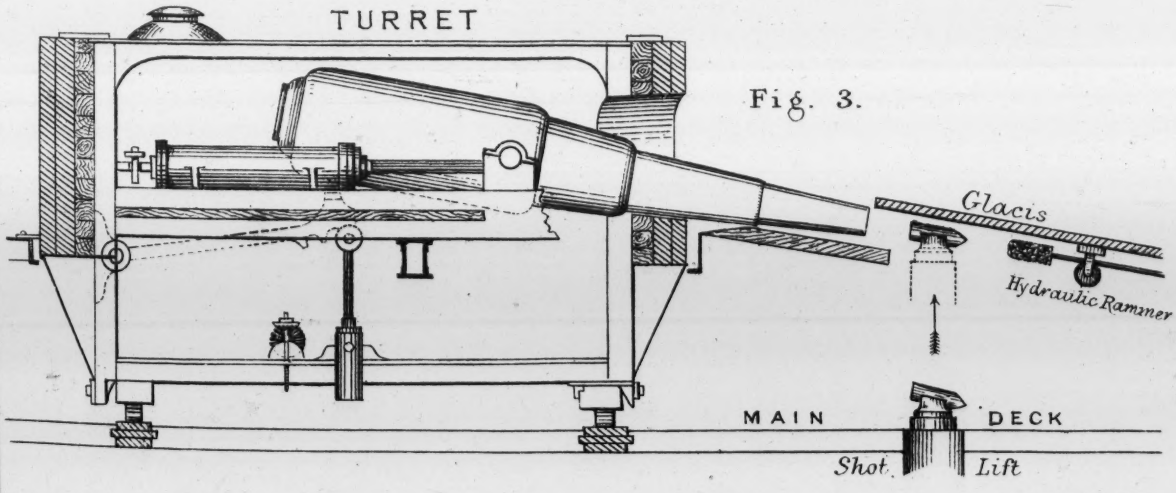


Fig. 3.

A.H.A. del. W. West & Co. imp.

The Inflexible and her Armament.

but quite sufficiently to resist the guns afloat in foreign navies at the time. Her armour was only 4½ inches thick, her heaviest guns were 68-pounders, weighing 95 cwt. Her immense length of 380 feet was exceeded by that of the *Minotaur* and her sister ship the *Northumberland*; but it was found that these long ships were not well adapted for manœuvring in line of battle, and later ironclads were made gradually broader in the beam, and shorter in the length from stem to stern. At the same time various minor improvements were introduced into the build, the most important of which was the change of the old oblique projecting bow into the almost perpendicular "swan-breasted" shape, which is substantially the same as that of the present running-down bow or ram. The armour was no longer restricted to the midship portion of our war ships; it was extended fore and aft, until they were completely covered above water and a few feet below it. The weight of the guns steadily increased, and with it the thickness of armour, while turrets and the tripod system of rigging were employed to give a concentration of fire on any desired point. The *Bellerophon*, with 12-ton guns, was given 6-inch armour; the *Hercules*, with 18-ton guns, armour of 9 inches; the *Devastation* carries 35-ton guns and armour of 12 inches on her sides, and 14 on her turrets; and the *Inflexible*, now building at Portsmouth, will have armour two feet thick and four 81-ton guns.

This turret ship is remarkable as the highest development of the modern fighting ship—for that is the best way to describe her. The navies of Europe are fast being divided into ships for coast defence, for cruising, and for action in line of battle in great naval engagements; and while fully available for the first of these purposes, the real object of the *Inflexible* is the last. There cannot be a doubt that she will be the most powerful man-of-war ever launched, though he would be a rash prophet that would predict that she will not ere long be left behind in the race of improvement by some still more formidable turret ship.

The *Inflexible* will be 320 feet long on the water-line, and will have a breadth of beam of 75 feet. The hull will consist of two parts—the main substructure and the upper portion; the former being an iron hull, no part of which will be less than six or seven feet under water. It will be built with a ram-bow and provided at the stern with a rudder and a pair of twin screws. On this is erected the armoured central or fighting portion of the ship, which will have a height of 10 feet above the water-line, and will be 110 feet long. Upon its deck will be the two turrets, each armed with a pair of 81-ton guns. At both ends of this midship section rises a lighter structure of the same height, but having along its centre, running fore and aft, deck-

houses 10 feet long and 30 feet wide (Fig. 1, Pl. CXXXI.). The deck-houses being prolonged to the bow and stern, will give a poop and a forecastle for working the anchors twenty feet above the water. A broad bridge passing over the turret-deck will connect them, and thus give an even upper deck 30 feet wide and more than 300 feet long, extending from stem to stern. The position of the turrets in the *Inflexible* has been made the subject of a novel arrangement. They are placed at each end of the central deck—not in an even line with each other, but diagonally at opposite corners of it, so that one turret is on the starboard and the other on the port side. The effect of this arrangement is that all the four guns have an uninterrupted range of fire all round the horizon. In firing ahead or astern the guns are trained so as to send their shot over the level portions of the deck on either side of the deck-houses (Fig. 1). In firing to starboard the port turret unites its fire with that of the starboard turret by aiming under the bridge, and *vice versâ*. Thus while in all our other double-turreted ships there is a fire of four guns on either beam, but of only two guns ahead or astern, the *Inflexible* will be able to direct her four guns at an object in any direction with respect to herself. The ship will have two or three masts, jury-rigged; none of the stays or running rigging will be brought down to the lower deck so as to interrupt the fire of the guns, all the working of the ship being carried on on the upper platform. Thus, by a simple and novel arrangement, the turret-system has been brought to what we may call perfection.

The *Inflexible* will have four sets of engines, with an aggregate of 7,000 horse power. Her full speed, with both screws going, will be 14 knots an hour; but on ordinary occasions she will be able to economise fuel by working only one screw and its engines. At the speed of 10 knots an hour she will be able to carry coals for a cruise of 3,000 knots, or twelve and a half days, which is about the average coal-carrying power of the best ships of our ironclad fleet. She will also be able to use some auxiliary sail-power; and, independent of this, her try-sails will be valuable in steadying her, and keeping her head to the wind in heavy weather.

Only the central portion of the ship and the two turrets will be armoured, the former with two feet, the latter with a foot and a half of armour, for even if the lightly built ends were riddled with shot, the ship would still keep afloat. In these ends are the coal-bunkers; when full it would make very little difference even if water got in among the coal, and when they are empty the ship would be much lighter, and have more floating power. But whether empty or not, the ends will not be wholly unprotected. A narrow passage will lead round them at

the water-line, just inside the inner skin of the ship. The sides of this passage will be lined with cork, so that a shot passing through it will make a small clean hole. At various points in the passage masses of packing will be ready to be shoved backwards or forwards to the place where the shot has passed through, so as to block up the passage there, and stop the hole until it can be properly plugged. The armour of the central portion will be the heaviest ever yet floated. It will be no less than two feet thick; but this does not by any means express its full resisting power, for it is arranged on a new system which will materially increase its strength. It will be bolted on in two layers, each 12 inches thick, but between these there will be a 9-inch layer of solid teak, and behind the whole a heavy teak backing, and then the iron framework of the ship's side. Now a shot from a very powerful gun, on striking this bulwark of wood and iron, would probably penetrate the outer plate, but in doing so it would be broken in several fragments; and these, after tearing their way through the layer of teak, would encounter the inner plate. Thus it is unlikely that even a shot from the 81-ton gun could penetrate such armour, and it would probably require several shots striking in succession on the same spot to make a breach. As yet this is only theory, but there is very little doubt that it would be confirmed by experiment. It would be well worth the cost of putting up a target at Shoeburyness and sending the 81-ton gun down there. Compared with the twelve-inch armour of the *Devastation*, it has been calculated that the strength of the armour of the *Inflexible* is as $2\frac{1}{4}$ to 1; but the calculation has been based only on the thickness of the iron, the element of strength derived from its peculiar arrangement being left out of account, and the comparative resisting power of the armour of the *Inflexible* must be very much higher. With this immense mass of metal on her sides, with 18 inches of it on her turrets, and an armament of four 80-ton guns, her displacement is 10,866 tons, but she will have three feet less draught of water than the *Dreadnought*,* though that ship will carry only 14-inch armour and four 35-ton guns.

But the ram and the torpedo are now weapons perhaps even more formidable than the gun; and while her armour may be relied upon to protect the *Inflexible*, at least from any gun now afloat, ample care has been taken to obviate as far as possible the dangers of ram and torpedo attacks. The handiness of the ship with both her screws going will make it very difficult for

* The greatest draught of water of the *Dreadnought* will be between 26 and 27 feet. Until a few weeks ago and before her change of name the *Dreadnought* was known as the *Fury*.

a hostile ram to give her a fair blow, but should she receive injury her peculiar structure—by which she is divided into an under and upper portion, with numerous water-tight compartments—would keep her afloat even with a large breach in her side. In addition to the ordinary bulkheads running across the ship, she will have one dividing her amidships in the direction of her length, and separate bulkheads specially constructed to isolate and protect the engines and boilers. In all, she will contain no less than 127 water-tight compartments; but numerous as they are, care has been taken to plan them so as not to interfere with the working of the vessel. The bottom will be double, and divided into several cells, in order to prevent any extensive injury from the explosion of a torpedo.

The armament of the *Inflexible* will be composed of four of the heaviest guns ever constructed, of which the experimental 81-ton gun now being tested at Woolwich is the type. Fig. 2 is a sectional sketch of the gun, showing the arrangement of the wrought-iron coils welded round the massive central steel tube. This tube, which forms the core of the gun, is bored out of a solid ingot, which cost about 1,700*l*. The bore is 24 ft. long, and rifled from the muzzle to within a few feet of the base of the tube, where the unrifled portion forms the powder chamber. The greatest external diameter of the gun is 6 ft.; at the muzzle it is just 2 ft. in diameter. The full calibre of the piece will be 16 in. The experimental gun has as yet been only bored out to 14½ in.; for the second series of experiments it will be given a calibre of 15 in.; it will then be bored to the full calibre of 16 in. and finally tested. Meanwhile the four guns which are actually to be mounted in the turrets of the *Inflexible* are in process of manufacture at Woolwich Arsenal.

The following are the approximate weights of the charges and projectiles for the various calibres of the 81-ton gun:—

Calibre. inches.	Charge. lbs.	Projectile. lbs.
14½	220	1,250
15	250	1,350
16	300	1,650

The 16-in. shell of the 81-ton gun will weigh nearly three-quarters of a ton; the bursting charge will be about a hundred pounds, that is, a whole barrel of gunpowder. Only the first series of experiments (those with the calibre of 14½ in.) is complete, and the gun is now being bored out to 15 in. The experiments occupied four days—Sept. 16, Nov. 18, and Dec. 9th and 10th, and gave excellent results. The coils and the steel tube bore the enormous strain without receiving the least injury or displacement, while the gun gave a very high initial velocity to

its projectile, and there is little doubt that at 1,000 yards it would penetrate 20 in. or even 24 in. of armour. At 250 feet the flat-headed bolts used in the experiments were buried 50 ft. in the sandy butt at the end of the proof-ground. The experiments have shown, too, that the action of the pebble powder is perfectly under control; that by using the various sizes a greater or less velocity can be given to the shot, a greater or less strain brought to bear upon the gun. By means of Major Maitland's gas-check all windage is stopped, and thus none of the force of the powder is wasted, and the bore and rifling of the gun is saved from erosion by the gas escaping round the shot, which wears out muzzle-loading guns more rapidly than any other agency. Maitland's gas-check consists of a plate of copper with a heavy rim attached to the base of the shot. On firing the charge the soft copper is forced into the grooves, and stops the windage. This gas-check is now in use throughout the whole of our heavy artillery. The flat-headed projectiles used in the trials of the 80-ton gun weighed, including the gas-check, about 1,260 lbs. The powder used in the charges was the large cubical pebble powder described in the POPULAR SCIENCE REVIEW in January last.* The following table shows the velocities and maximum pressures in the powder chamber on each occasion:—

September 17, 1875.

Round.	Charge. lbs.	Description of Pebble Powder.	Initial velocity. Feet per second.	Pressure on gun. Tons per sq. inch.
1	170	1·5 inch cubes	1,393	24·2
2	190	1·5 „ „	1,423	22·3
3	210	1·5 „ „	1,475	24·8
4	220	1·5 „ „	1,503	22·2
5	230	1·5 „ „	1,550	29·6
6	240	1·5 „ „	1,551	27·3

November 16, 1875.

1	220	1·5 inch cubes	1,525	25·8
2	220	1·7 „ „	1,420	20·6
3	230	1·7 „ „	1,454	20·2
4	240	1·7 „ „	1,470	21·0

December 9, 1875.

1	220	1.5 inch cubes	1,535	24·1
2	220	1·7 „ „	1,502	23·0
3	220	2·0 „ „	1,485	21·7
4	230	1·7 „ „	1,543	24·9
5	230	2·0 „ „	1,498	23·4
6	240	2·0 „ „	1,513	23·0

* Article, "Gunpowder, its Manufacture and Conveyance." By A. Hilliard Atteridge. January, 1875.

December 10, 1875.

Round.	Charge. lbs.	Description of Pebble Powder.	Initial velocity. Feet per second.	Pressure on gun. Tons per sq. inch.
1	220	1·5 inch cubes	1,440	28·1
2	220	1·7 „ „	1,414	25·1
3	220	2·0 „ „	1,366	24·4
4	250	2·0 „ „	1,523	24·8

Rounds 1, 2, 3 of December 10 gave exceptional results, as they were fired with a projectile of 1,460 lbs. and consequently the velocities obtained were much lower and the pressures proportionally higher than with the smaller projectile ordinarily employed. It will be observed that pressure and velocity increased with the weight of the charge, but decreased as the size of the pebbles was augmented, the pressure, however, decreasing in a much greater ratio than the velocity. Thus the action of the charge is completely under control.

It has been assumed that it will be well to keep the pressure of the gas in the powder-chamber below 25 tons per square inch; and these experiments show that this can be easily accomplished, while at the same time giving a very high initial velocity to the shot. When the gun is bored out to its full calibre, it will probably give even more striking results.

Mounted on the ordinary carriages and slides, and worked by manual labour, these huge guns would be almost unmanageable, and at best would deliver only a slow inefficient fire. But all difficulties in the way of using them with good effect have been removed by an invention of Mr. Rendel, of the Elswick Works, which will make these monster pieces of artillery more handy than even the old 68-pounders.

The leading features of the arrangement are shown in fig. 3. Two guns will be mounted side by side in each turret. Each gun will be mounted so as to be supported on three points. The trunnions will rest on blocks sliding on fixed beams bolted down to the floor of the turret, while the breech will rest on a third block, sliding like the others between guides, upon a beam or table. Behind each of the trunnion-blocks, in the line of recoil, are two hydraulic cylinders, connected with them by piston-rods. The cylinders communicate by a pipe, on which there is a valve, that on the recoil of the gun opens and allows the pistons of the rams to run back slowly, checking the recoil. By reversing the apparatus, the gun can be run out again. The beam on which the breech rests is supported by a third hydraulic ram, fixed vertically beneath it in the turret. By this means the breech can be easily raised or lowered, thus elevating or depressing the muzzle of the gun, which pivots on its trunnions with a large preponderance towards the breech.

In order to load, the muzzle is depressed until it comes opposite to an opening made in the upper deck before the turret, and protected by a sloping armoured glacis. A hydraulic rammer works in guides through this hole, and the rammer-head is hollow, and is so constructed that when it is driven into the recently fired gun, and comes in contact with the sides of the powder-chamber, a valve opens, and it discharges through a number of holes small jets of water, thus acting as a sponge, and extinguishing any remnants of the charge or of the products of the explosion which may have remained smouldering in the bore. It is then withdrawn, and a hydraulic shot-lift raises up to the muzzle of the gun the charge, the projectile, and a retaining wad, and then a single stroke of the rammer drives them into the gun and home to the base of the bore. Again the rammer is withdrawn, the hydraulic ram under the breech of the gun elevates the muzzle, the turret swings round, and the shot is fired. A 9-inch gun, mounted experimentally in a turret at Elswick, and loaded on this system, was brought to the loading position, sponged, loaded, and brought back to the firing point in twenty-three seconds. Equally rapid loading was effected with the 38-ton gun during the experimental trial of the hydraulic gear on board the *Thunderer*. Thus the first advantage of the system is rapidity of fire; the second is economy of labour. One man only for each gun is stationed in the turret, another works the hydraulic rammer on the main deck, six or eight others are employed in bringing up the ammunition to the shot-lift by means of a small tramway. There are two sets of loading gear for each turret; but even if both were put out of order, the gun could still be loaded, with an ordinary rammer and sponge, by a number of men stationed on the main deck.

The adoption of the system enables very heavy guns to be carried in comparatively small turrets. Those of the *Inflexible* are very little larger than those of the *Devastation*; so that with the old plan of having a numerous crew in the turret, and running in the gun in order to load it by hand, only the 38-ton gun could be carried. As it is, it is quite possible that the *Inflexible* will be armed with even a more tremendous weapon than the 81-ton gun. This has been held in view in designing the ship; and, by a slight modification, it will be possible to mount in each of her turrets a pair of 160-ton guns, with a bore of 30 feet and a calibre of 20 inches.

A minor feature, which will perhaps be introduced in connection with guns of large calibre, is a steel plug containing within it a detonating apparatus for firing a charge of powder. This is intended to be fixed in the vent of a heavy gun, in order to prevent the upward escape of the gas and the consequent

gradual erosion of the vent. This erosion very rapidly widens the vent, and at last disables the gun, and the fire has to be suspended until it is revented. Thus this system of firing, which has been invented by Capt. Noble, R.A., would greatly increase the efficiency of the gun.

Some idea of the amount of ammunition required for the 81-ton gun will be given by the following calculation :—Let us suppose that in an action the *Inflexible* would fire only ten shots from each of her guns; she would use up more than 1,300*l.* worth of ammunition, burn upwards of 100 barrels of pebble powder, and hurl nearly thirty tons of iron at the enemy.

As a new type of man-of-war, we may sum up the leading features of the *Inflexible* as follows :—The armour is confined to the central fighting portion, and to the main substructure which floats the ship. An armoured deck, seven feet under water, divides the vessel into two separate portions. The unarmoured ends are so constructed that the vessel will float even when they are penetrated. The ship has a wide beam and a comparatively light draught. The deck-houses give a high bow and stern, and the turrets are so arranged as to enable all four guns to be fired both ahead and astern, or on either beam. The *Inflexible* has been accepted as the type of our future line-of-battle ship; a few years may perhaps introduce into naval warfare such changes as to render the principles on which she has been constructed obsolete. But with our present knowledge no better design could be adopted, and already the Government has determined on immediately laying down two new ships of the same type, but of smaller size. They are to be called the *Ajax* and the *Agamemnon*. Their displacement will be about 8,000 tons—that of the *Inflexible* is 11,000. They will carry 18-inch armour on the central section, and two 38-ton guns in each of their turrets.

NOTE.—The deck-plan of the "Inflexible" is only a rough sketch intended to show the arrangement of turrets, decks, &c., in order to obtain a fire, ahead, astern, and on either beam, for all four guns.

X 3000

Fig. 5.

X 3000

Fig. 4.

X 500

Fig. 3.

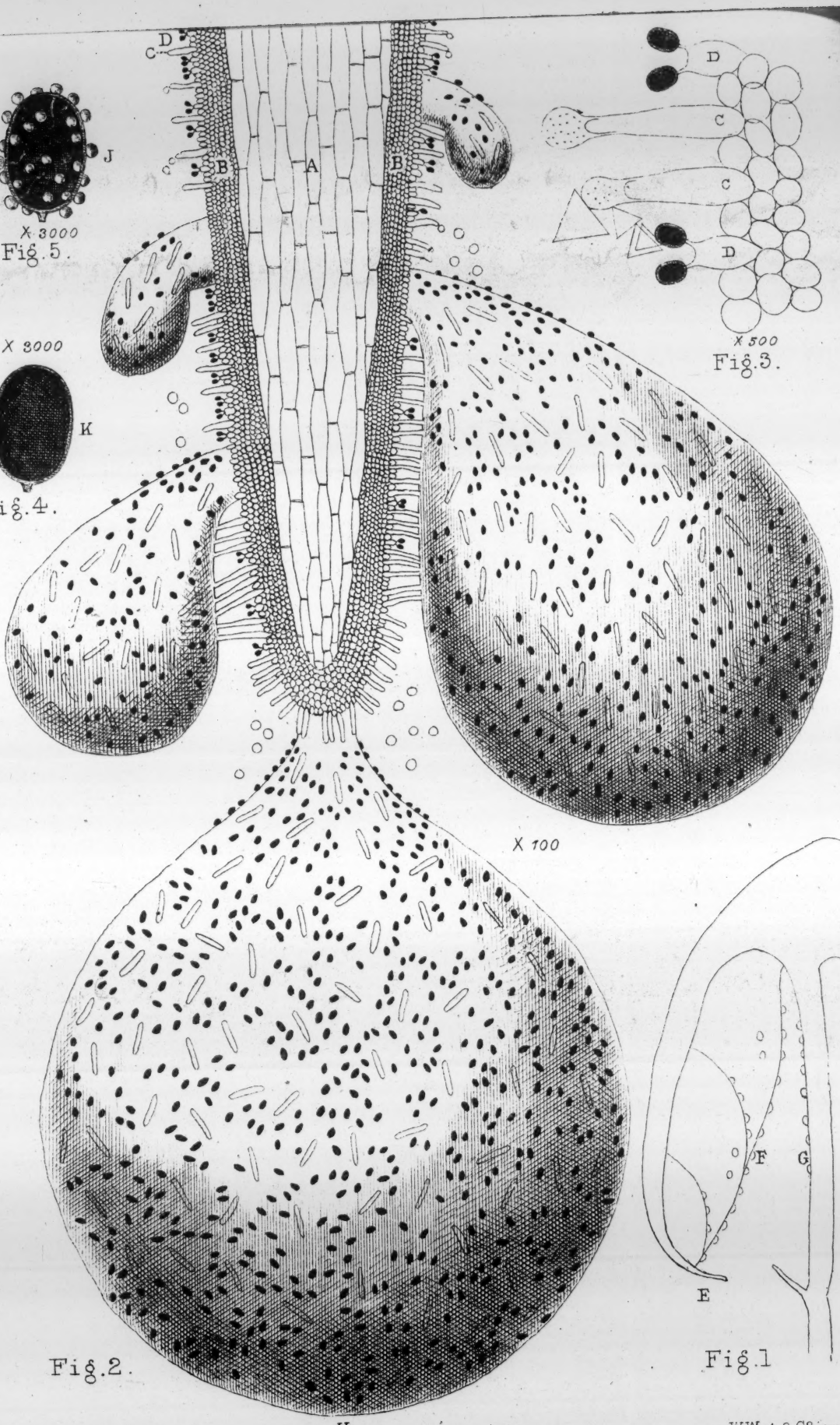


Fig. 2.

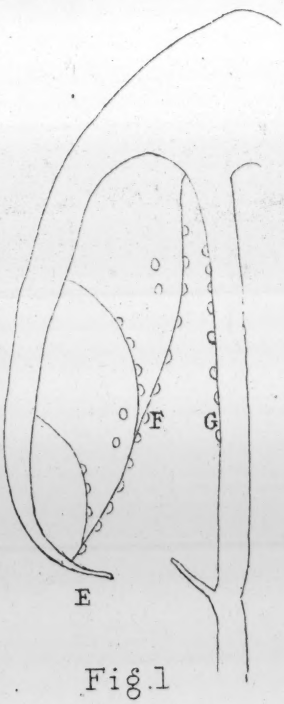


Fig. 1

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Reproduction of Agaricus lacrymabundus.

HOW MUSHROOMS ARE REPRODUCED.

(*Agaricus lacrymabundus. Fr.*)

By WORTHINGTON G. SMITH, F.L.S., M.A.I.
F.R.Hist.S. Ireland, &c.

[PLATE CXXXII.]

POSSIBLY there is no branch of fungology so little understood as the reproductive process in the *Hymenomycetes*, of which family our common mushroom is a good example. Professor Sachs, in his recently published "Text-Book of Botany," in referring to the *Basidiomycetes* (of which the *Hymenomycetes* is one family), says: "Although the largest and most beautiful fungi belong to this order, yet their course of development is at present only very imperfectly known. In contrast to the variety of form occasioned by the alternation of generations in most other fungi, and to the singular phenomena of the mycelium of the *Ascomycetes*, it is remarkable that similar processes have not yet been established in this class. The origin from the mycelium of the usually large receptacles, and their further development, are known in their more conspicuous features, as is also the mode of germination of their basidiospores; but the history of the mycelium before it forms the receptacle is still unknown. "I must therefore," says the professor, "content myself with a few morphological explanations of the development of the latter in the most striking forms of the *Hymenomycetes* and *Gasteromycetes*." Unfortunately for Professor Sachs, the English editors of the "Text-Book" refer to Œrsted's observations of the reproductive process in *Agaricus variabilis* as reproduced in the "Quarterly Journal of Microscopical Science" for 1868, p. 18. As Œrsted founded his conclusions upon mycelium gathered from a mushroom-bed where *A. variabilis* is (as far as my experience goes) never found, his deductions lose a great deal of their value. Indeed, nearly the whole subgenus to which *A. variabilis* belongs is peculiar to decayed wood and moss. Formerly *A. variabilis* was included in the subgenus Crepidotus, but Professor Elias

Fries, of Upsala, following the views not long since published by the writer of these lines, now places the species in a new subgenus of Agaricus,—Claudopus (*Hymenomycetes Europæi, Epicriseos*, p. 213), and says, under *Agaricus* (*Claudopus*) *variabilis*: "Ad ligna et truncos emortuos, præcipue Abietis."

In illustration of the hymenium, or reproductive surface of the gills in the *Hymenomycetes*, Professor Sachs gives a figure of the minute structure of the common mushroom (*Agaricus campestris*). But, unfortunately, the figure and description alike are far from correct. Sachs says the basidia in this species produce only two spores, whilst in other *Hymenomycetes* the number is usually four, and the illustration is made to accord with the description. But the fact of the case is that there *are* four spores produced in each basidium in *Agaricus campestris*, and this fact does not apply to *A. campestris* alone, but to every variety of it, and every variety of its numerous allies, of which the common horse mushroom (*A. arvensis*) is one. The nature of the hymenium of the common mushroom is correctly figured by Dr. M. C. Cooke, in the "POPULAR SCIENCE REVIEW" for Oct. 1869, Pl. LIII. fig. 14, where each basidium is shown, furnished with four (not two) spicules. Each of these spicules normally bears a spore, but it is a common thing in Agarics for the four spores to be produced two at a time, diagonally; as the first two spores become ripe, two other and younger spores appear on the spicules at right angles with the first, and the two latter push the two former off. Sachs was evidently unacquainted with this fact. Seeing only two spores at a time on the basidia of the mushroom, he overlooked the fact that two had already been pushed off, or were not yet produced. It is, however, quite common to see all four spores produced at the same time in the mushroom, so that there is not the slightest foundation for reducing the basidia in *Agaricus campestris* to the production of two spores only. Le Maout and Decaisne, in their "Descriptive and Analytical Botany," p. 953, correctly figure the basidia in *A. campestris* with four spores; but, unfortunately, the description of reference to the basidia and the analogous organs (cystidia) is far from correct. These authors are still more incorrect under their description of *Geaster hygrometricus* (p. 956), one of the starry puff-balls, and, like the mushroom itself, one of the *Basidiomycetes*. This species is described by Le Maont and Decaisne as a hypogeal globose plant, which, they say, presents the following curious phenomenon: "when mature and still underground, if the season be dry, the outer envelope, which is hard, tough and hygrometric, divides into strips from the crown to the base; these strips spread horizontally, raising the plant

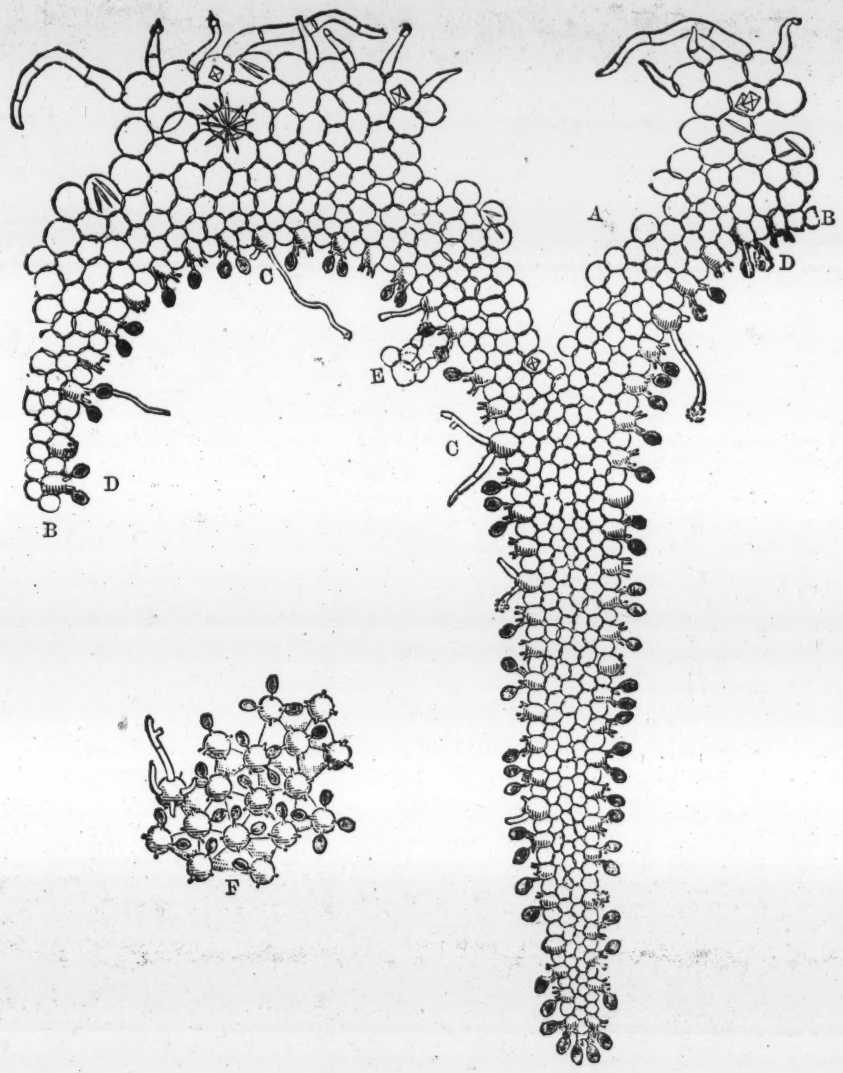
above its former position in the ground; on rain or damp supervening, the strips return to their former position; on the return of the drought, this process is repeated, until the Fungus reaches the surface, becomes epigeal, and spreads out there; then the membrane of the conceptacle opens to emit the spores in the form of dust." This description is altogether incorrect; in fact, just the opposite state of things holds good, for the strips become horizontal from moisture, and are rigidly inflexed when dry. Fries pointed this out, in his "Systema Mycologicum," nearly fifty years ago. These errors, in our best and most recent text-books, are here pointed out, not from any desire to find fault or detract in the slightest degree from two thoroughly excellent works, but simply to show how difficult it is to make new and correct observations. In the following paper and the one recently published by me, on the reproduction of *Coprinus radiatus*, in the "Gardeners' Chronicle" for Oct. 16 and 23, 1875, I have, to a certain extent, broken fresh ground. My views, although long since foreshadowed by various competent botanists, are yet different from those now generally held regarding the reproductive process in the *Basidiomycetes*. If I am in error as to my supposed facts, or the deductions I draw from them, I am at least in good company, and I have not warped any of my observations to fall in with the previously expressed views of any other writers whatever.

The nature of the gills in various members of the mushroom tribe differs very much, and this difference is especially remarkable in the absence or presence of the trama, and in the number, form, and size of the cystidia. In the genus Coprinus there is no trama to the gills. The trama in true Agarics is formed by cells, which are of a different nature from the other simple cells which go to form the gills, and this trama forms the intermediate substance between the hymenial surfaces.

Nothing can be more different than the interior structure of the gills in the genus Coprinus, and in *Agaricus lacrymabundus* (Fr.). In fig. 1 is shown, enlarged 150 diameters, a vertical transverse section down a gill of *C. radiatus* (Fr.), which species is (though minute) quite typical of the entire genus. The trama with its large cells would, if present, be at A; but a glance at the figure will show that the individual cells throughout this section are almost identical in size. If reference is now made to the similar section of a gill belonging to *A. lacrymabundus*, Fr. (and shown on Pl. CXXXII.), the nature of the cells at A, which go to form the trama, will be quite apparent. Wide differences of cell-form like this are common in the mushroom tribe, but the difference of form as found amongst the cystidia is still more striking. In *Coprinus*

atramentarius (Fr.) the cystidia are indeed so large that each individual cystidium would hold within itself more than 300 of the ordinary cells which go to build up the pileus. These facts

FIG. 1.



W.G.S. AD. NAT. SC.

COPRINUS COMATUS. Fr.

Vertical section and surface (F) of Gill enlarged 150 dia.

regarding the cap and the hymenial surface (to say nothing of the gills often completely separating from the horny hymenophorum, as in Paxillus), and many other known facts in regard to the nature of the stem and its outer surface, go far to dis-

prove the hypothesis that the higher fungi found under the Agaricini may be generalised as mere concreted masses of moulds. No bringing together into a mass of a forest of Penicellium could even make an Agaricus, and to me there is nothing in common between the conidio-spores of Penicellium and the basidio-spores of the Agaricini.

The various bodies which, as I believe, belong to the reproductive process in the mushroom tribe are seen in figs. 1 and 2 and Pl. CXXXII. The peculiar cells of the trama are shown at A, Pl. CXXXII., the simple cells which form the external and hymenial surface at B, and the privileged cells at C, D. C shows the cystidia and D the basidia. Each basidium in the Agaricini bears four minute spicules, which carry the same number of spores. The difference in size between the basidia and cystidia is often immense, and in *Agaricus lacrymabundus* the perfect forms of the two organs are very different from each other; they, however, so approach each other in this species, that every intermediate form between a cystidium and a basidium may be observed. In *Coprinus radiatus*, as I have shown elsewhere, the cystidia have their contents differentiated, and at once produce spermatozoids; or they germinate, and the spermatozoids are produced from a differentiation which then takes place at the end of the thread; these spermatozoids attach themselves to and ultimately pierce the spores, and their piercing causes the discharge of a single cell from the pierced spore, which cell belongs to the pileus of the new plant. As I interpret my observations, this process is carried on upon the gills themselves, as shown in fig. 1, and at the time of the perfect maturity of the fungus, at least in Coprinus, in the subgenus Volvaria, in the ordinary mushroom, and in such plants as have fallen under my notice. The basidia with their spicules and spores, the cystidia germinating and bearing spermatozoids, and the first cells of a new plant (E), are all shown in position in fig. 1.

Agaricus lacrymabundus (Fr.) is a very different plant from *Coprinus radiatus*. It is one of our commonest Agarics of the autumn, and is usually found in damp pastures and about stumps. It bears a considerable resemblance to the common mushroom, and is without doubt often gathered for the table in mistake for that species, but whether with any ill effects or not I am unable to say. The most striking character of this Agaric resides in its gills, which are always furnished with a white edge, which drips with semi-milky tear-like drops. Why this singularly good character is not given by Berkeley in his "British Flora," or his "Outlines of British Fungology," or by Dr. Cooke in his more recent "Handbook," I cannot say. Indeed, Fries himself (whose species it is) does not advert to this salient charac-

ter in his "Systema Mycologicum," or in either editions of his famous "Epicrisis." In the "Monographia Hymenomycetum," Fries, however, says, in reference to the gills of this plant, "acie albicante et jove udo plorante."

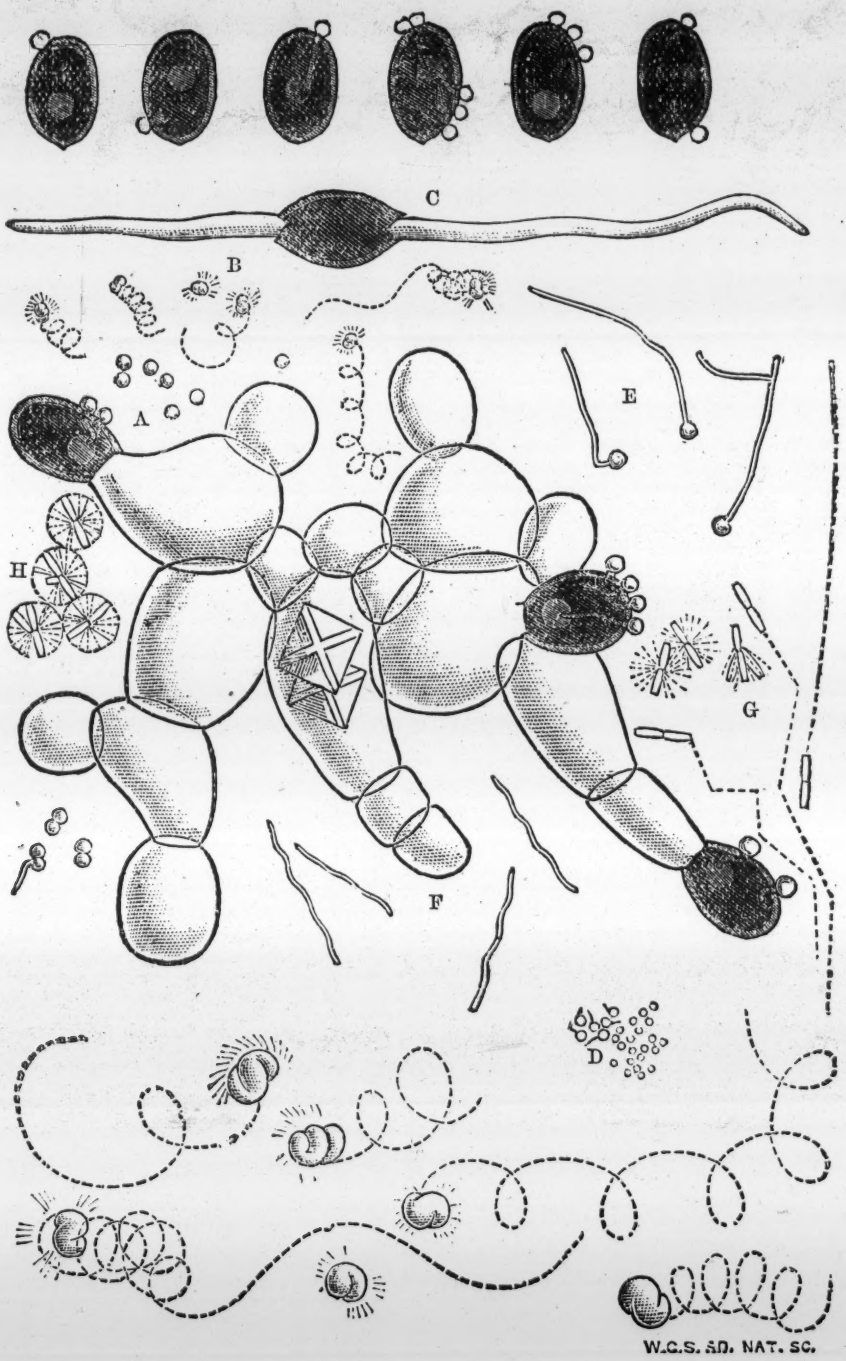
Part of a section of a specimen of *Agaricus lacrymabundus* is shown at E, Pl. CXXXII., with the characteristic drops *in situ* on the gills and upper portion of stem, F G. The drops are shown towards the edge of a gill enlarged 100 diameters at H, above which may be seen several drops of a smaller size, which may or may not at length coalesce with the lower drop. These drops invariably dry up on the edges and surface of the gills. As far as I know, milky tears peculiar to *Agaricus lacrymabundus* have never been minutely described, neither has an account of any microscopical examination of them been hitherto published.

These drops are distilled direct from the cystidia. When the fungus reaches maturity the cystidia protrude boldly from the surface of the hymenium, as seen at C; and the apex of the cystidium opens exactly as does the ascus in Peziza. At first the cystidium is filled with a thin fluid in which no granules can be detected; but at length a large vacuole is formed at the base of the cystidium, and the contents are forced towards the apex: here the fluid becomes partly differentiated into granules, and at length the cystidium opens at the top and discharges its contents. The protruded drop now swarms with moving atoms of a regular size, which I refer to spermatozoids. They are in every way identical with the spermatozoids of *Coprinus radiatus* (Fr.).

In my recent paper on the reproduction of *Coprinus radiatus* I adverted to the fact of the cystidia falling bodily away from the hymenium, and exactly the same phenomena holds good in *Agaricus lacrymabundus*; for if a drop of the liquid from the gills is examined under the microscope it will be seen to swarm with free cystidia which have dropped into the fluid from the gills; this liquid not only abounds with spermatozoids and systidia, but it also swarms with spores which have fallen away from the basidia, as seen in Pl. CXXXII.

If the spores which have fallen into the drop are examined, they will be found to be very different in aspect from the spores as they are seen upon the basidia; for whilst the spores in the latter position are perfectly plain in outline, as seen at J, enlarged 2,000 diameters, the spores within the drop are studded all over the surface with the spermatozoids discharged from the cystidia. Not only are the spores studded as shown at K, but they are pierced through the external coat by a fine thread protruded from the spermatozoid. The effect of this is that a single free cell is soon after discharged from the spore, and this

FIG. 2.



COPRINUS RADIATUS. Fr.]

Spores pierced by Spermatozoids; unpierced Spore germinating at both ends; infant plant and infusoria enlarged 1,000 diameters; Spermatozoids at bottom of plate further enlarged 3,000 diameters

floats about in the drop, leaving the exospore quite empty. This single transparent cell, which is three or four times the size of the original spore, and is the first cell of the pileus of a new plant, is in its turn commonly attacked and pierced by the spermatozoids. Sometimes a spore is surrounded and pierced by a large number of spermatozoids, whilst at other times it receives the attack of one body only; this is, however, sufficient, for I have frequently seen the first cells discharged from the orifice made by a single spermatozoid, and the latter body again pushed out by the cell. The spermatozoids which have a single turn of a spiral revolve rapidly, and, when they come in contact with a spore, not unfrequently creep with an amœba-like movement over the surface, before they discharge their contents into the protoplasm of the spore. These bodies, as seen in *Coprinus radiatus*, are shown in the accompanying figure, enlarged to 1,000 and 3,000 diameters, and they are precisely the same in *Agaricus lacrymabundus*. When the spermatozoids of the latter species emerge they are dark brown in colour, and here they resemble the spores; the at first colourless contents of basidia and cystidia alike become at first differentiated and then oxidised on exposure to the air. In a minute species like *Coprinus comatus*, where the growth of the plant is very rapid, and hundreds of generations are produced in one season, new plants are rapidly reproduced from the spores, and the growth can be watched; but in *Agaricus lacrymabundus* the case is very different, for it is probable that it would take many months (if not a whole year) to grow a perfect fungus belonging to this species from the spores. It must also be remembered that although this Agaric produces many millions of spores, yet the plant does not increase in actual numbers; for if all the spores produced plants, then in one year the world would be covered with this species only. For one spore which grows, hundreds of millions must be failures. In a former paragraph reference was made to bodies intermediate in form between cystidia and basidia, and bodies of this nature are common on the upper part of the stem in *Agaricus lacrymabundus*; they are shown on the natural size section at G. The bodies in this position secrete and distil a semi-milky fluid, which they excrete in drops, which drops are invariably dotted all over the upper portion of the stem. It must not be thought that this distillation is peculiar to the species under notice, for it is a character (though till now unpublished) of whole sections of Agarics. For instance, certain groups coming under Tricholoma are described by Fries as "lamellis decolorantibus, rufomaculatis l. cinerascentibus." Now these brown spots on the gills, when examined under the microscope, are seen to be produced by a liquid which changes colour, and which is distilled

from the cystidia; and it is quite possible that the same phenomenon holds good in many other fungi, as in the tears of *Merulius lacrymans*, and in the drops found upon such species as *Polyporus dryadeus*, *P. hispidus*, *P. cuticularis*, and many others. It seems probable that in some species this liquid, which by a differentiation produces spermatozoids, also sends the spores into a temporary resting condition, and that the spores rest before germination, just in the same way as many seeds rest. This would explain the great difficulty of getting some fungus-spores to germinate. Under any circumstances diverse fungus-spores resemble seeds in the fact of some germinating at once, whilst others will not germinate till long periods of time have elapsed.

On examining the semi-milky drops as seen on the stem, I have been unable to observe any production of spermatozoids, but these intermediate cystidium-like bodies are expelled from the stem and fall into the drops of moisture distilled. This is a state of things to be expected, for as these bodies belong to neither basidia or cystidia, they are as a consequence quite as unable to produce spermatozoids as spicules and spores. In Agarics and Boleti the stem may be considered as a mere barren hymenium; when the stem is striate (as it commonly is), these striæ represent the absent gills; in species with decurrent gills, the fruiting surface (as in *Agaricus prunulus*) sometimes quite reaches the ground. When the stem in Boletus is reticulated, the reticulations represent the absent tubes, so that it should be a matter of no surprise to find organs pertaining to the hymenium upon the stem. The external surface of the pileus, for the same reason, often bears besidia and spores, and the stuffed stem and cartilaginous bark answers to the trama and hymenial surface. An Agaric or Boletus with the pileus and gills arrested would answer to a Clavaria bearing fruit all over the club, and abnormal Agarics are sometimes found in this condition, whilst the simplest form of *Hymenomycetes* is where a merely filmy hymenium is developed, as in Hymenula.

When it is remembered how innumerable are the myriads of spores and spermatozoids set free every autumn, and how probable it is that hybrids of every degree are produced from these bodies, the diverse and almost countless forms seen in the mushroom-tribe quite cease to be a matter of wonder. Without doubt the spermatozoids of some species commonly pierce the spores of an ally, and so produce plants intermediate between one species and another; such forms are an everyday experience with fungologists and lichenologists, and the more one knows of species as species the greater are the difficulties to be surmounted in correct naming. Fries himself says, under Mycena, that he has only given the best marked species, and

that he knows in his mind many other apparently distinct forms and species which he has never published. Our cryptogamic floras require cutting down to at least one-fourth of their present dimensions by some competent botanist, who is well acquainted with species. In the majority of instances the species are so ill defined that it is the easiest possible matter to gather plants which it is simply impossible to refer to any described fungus, simply because the specimens gathered belong to none.

The spore, as found amongst Agarics, I consider female in the sense of its pertaining to the female in the same way as an unimpregnated ovum may be considered a female organ whilst still attached to the mother, and the spermatozoids male, as pertaining to the male in the same way as spermatozoids are always the direct offspring of the male (as ova are of the female). When the spore is pierced by the spermatozoid, the former is capable on germination of producing either or both sexes. If these views are correct, a term is required for the unpierced spore synonymous with the ovule in flowering plants, as distinguished from the seed; and the old term sporule might well be used for indicating the unpierced spore. The spores in *Agarics* must be considered very different in nature from gemmæ, or buds, and they are totally different from the conidia or conidio-spores of Penicillum and the acro-spores of Mucor. The latter may reasonably be compared with the bulbils of Dentaria, and some Liliaceæ; but the nature of the basidio-spores (and of the hymenium which carries them) points to a very different conclusion. It is a very common thing for the mycelial threads of all sorts of fungi to break up into bead-like conidia, and as these conidia or secondary spores have a certain reproductive power, there is here certainly a slight analogy with gemmæ. The spores and spermatozoids in the Agaracini appear to me to have a strong analogy with the oosphere and spermatozoids of *Fucus vesiculosus*, the cystidia having an analogy with the antheridium in the same Alga. I have expressed an opinion elsewhere that Van Tieghem's idea of male and female spores in the Agaricini is altogether untenable; such a thing as a male ovum or spore is as unreasonable as a female spermatozoid or female pollen-grain. Seeds of all sorts are capable, on germination, of producing either or both sexes, though it is common enough to see one sex exalted at the expense of another. Even in the highest mammals the males have a trace of the female in the subordinate mammæ and other characters, and similar characters which show a trace of the male are found in most female animals.

In the vegetable kingdom nothing is more common than to find so-called male or female plants changing their characters. Males will, under altered conditions, carry female organs, and

females will produce anthers and pollen, which conclusively shows that not only are ovules, spores, seeds, and eggs not in themselves male or female, but the produce itself of these eggs is inherently hermaphrodite. It is convenient to name many animals and plants "male" and "female," because they are almost but not entirely so. Even in the case of the Equisitaceæ, Sachs is obliged to qualify his terms of regarding these plants, and say that on the germination of the spores "the prothallia are, *in general*, dicœcious" ("Handbook," p. 363). And on Ferns the same qualification of terms is found, for under the latter head he says (p. 343): "The prothallia *show a tendency* to be dicœcious."

Several papers have been published of late on the reproductive process in the *Basidiomycetes*, and the writers of these papers have noted (with me) the diverse mycelia seen amongst the germinating spores; but I am convinced that the threads which produced antherozoids, as seen by Van Tieghem, came from the cystidia and not the spores. When a mass of spores and threads are seen in a solution of horse-dung, nothing is more difficult than to decide for certain whether the threads really come from the spores or not, and the spores of *Coprinus radiatus* could not possibly have been "sown" on any decoction without cystidia likewise falling upon the liquid. The "rod-like" bodies described by Van Tieghem read remarkably like an illustration of the well-known fact of the threads of many fungi breaking up into Bacteria at the tips. In the many Agarics I have examined, it invariably happens with me that after a spore is pierced it discharges a single cell, which developes directly into a new individual, exactly as is seen in Chara, but an unpierced spore may produce a thread of indefinite length; now if this thread is attacked by the spermatozoids, it will in its turn produce this single primordial cell of a new fungus, or if the mere undifferentiated liquid contents of the cystidium should pass over the thread from an unpierced spore, it there gives rise (at the point of contact) to the primordial cells.

The persistence of form in spores, and especially the pierced spores, under extraordinary conditions, is something remarkable; for instance, repeated violent boiling has no effect on the form and colour of the spore, and in the cases where the spermatozoids are attached no amount of boiling disengages them; if anything, the boiling seems to make the piercing more distinct to the eye. I do not find conidia or gemmæ resist boiling in this manner, and certainly no bulbil or bud from a flowering plant would maintain its form under these conditions. As for the unpierced spores, I believe their life to be of the very shortest duration (not twenty-four hours), but after piercing the life remains, just as we find life slight in an ovule but enduring in a seed.

Dr. Max Reess has recently published an account of *Coprinus stercorarius* (which is a rare species and not British) in Pringsheim's "Jahrbücher," in which he has described and figured a sort of Carpogonium (or Ascogonium), a female organ said to be produced at the ends of mycelial threads. This organ, according to Dr. Reess' figures, would appear to be furnished, or not furnished, or doubly furnished at the apex with a trichogyne, an organ into which the spermatozoids discharge their contents. This trichogyne, according to Sachs in describing the Algæ, is "a long thin hair-like hyaline sac, which serves as a receptive organ, and springs from a structure which is called the trichophore. This latter is a body usually consisting of several cells, in or near which the results of the fertilisation become apparent, cell-filaments or masses of tissue shooting out near or beneath it, forming the receptacle, here termed the cystocarp, in which the spores are subsequently formed. In one genus (of Algæ), *Dudresnaya*, the process is still more complicated, inasmuch as the tubes first spring from the trichophore, which occasion the formation of the cystocarps only after conjugation with the terminal cells of other branches." The Carpogonia, as figured by Dr. Reess, remind me of a number of spores agglutinated together with spermatozoids still attached, exactly as similar agglutinated companies of spores may be always washed from the dry brown spots on *Agaricus lacrymabundus* or the various brown-spotted Tricholomata. I am disposed to fall in more or less with Dr. Reess' views, although I do not know the species he has worked upon. The single primordial cell which I have seen expelled from the spore of *A. lacrymabundus* and then pierced by spermatozoids before going into a resting state must be of the nature of a Carpogonium. The spores commonly put on an appearance similar to that figured by Dr. Reess, but anything referable to a tricogyne I have not seen.

Dr. Eidam has also recently published an illustrated paper on the reproductive process in the Agaricini in the "Botanische Zeitung" for the 1st and 8th Oct. last. Unfortunately, Dr. Eidam's paper has reference to *Agaricus coprophilus* (Bull), a rare Agaric in this country, and one almost unknown to me. Here, at fig. 12, Pl. VIII., a Carpogonium is again suggested, but Dr. Eidam very properly and reasonably attaches a note of interrogation to his interpretation of the figure. At the ends of certain threads Dr. Eidam figures what he terms spermatia, which, though somewhat different in shape, are identical in size with the bodies I term spermatozoids. My spermatozoids are at first globular, fig. 2 A, then somewhat elongated from the unfolding of one turn of a spiral B; and these bodies, with me, although often produced direct from the cystidium itself, are quite as often produced at the end of a long thread given out

from the cystidium. With me, I find the unpierced spores to burst at one or both ends, fig. 2 c, exactly in accordance with Dr. Eidam's figs. 1, 2. The ruptured end of the exospore from which the threads emerge are shown in my fig. 2 c, and are uncommonly well shown in Dr. Eidam's figs. 1, 2. In Dr. Eidam's plate the two orders of threads are well shown, but I am perfectly convinced that the second order of mycelial threads which bear the spermatia do not belong to the spores. These latter threads are shown by Dr. Eidam to a larger scale than the threads from the unpierced spores, and there are only three spores shown in connection with the spermatia-bearing threads. Now, although these three latter spores are shown to nearly double the scale of the other spores, yet in each case *the wall is shown unbroken.* This is simply because the walls belonging to these spores are correctly shown in the plate; the threads do not come from the spores (which have been merely accidentally washed against the threads), but from the fallen cystidia. In this plate there are no less than sixteen spores producing threads without spermatia, and *in every instance* the spores are then shown as *ruptured.* I am quite disposed to acquiesce in the correctness of Dr. Eidam's observations as regards the spermatia, but the spermatia-bearing threads are from the cystidia. Fig. 12 can hardly be a Carpogonium; it disagrees with Dr. Reess' figure and description, and quite accords with what I have seen of the terminal condition of a cystidium-thread when the contents are about to become differentiated. My impression is that any Carpogonium in the Agaricini must be a pierced spore or an agglutination of pierced spores. These spores or companies of spores may rest for longer or shorter periods, and the cells and mycelium when at length produced is then analogous with a subterranean rhizome, capable of producing new plants from buds.

It will be observed that the notes on both the species last referred to, as well as my notes on *Coprinus radiatus*, bear upon dung-born species of rapid growth. As dung swarms with fungi and infusoria of all sorts, the greatest care is necessary in experiments, or Bacteria will be mistaken for Spermatia, and Sphærobacteria for Spermatozoids. To clear up some little of the confusion which might arise as to all these bodies, the infusoria are engraved in fig. 2 to the same scale as the spores and bodies referred by me to spermatozoids; A shows the globular spermatozoids as they are at first produced within the cystidium, or within the end of a thread more or less long, protruded from a cystidium: these bodies are at first motionless, but after being kept in liquid for a few hours they begin to slowly revolve; this movement keeps on for several days, and is all the time accelerated, whilst the body (formerly spherical) now becomes slightly

elongated, and a single turn of a spiral is seen as in the larger figures shown at the bottom of the plate; the dotted lines indicate the whirling motion of the spermatozoids. For comparison with this, various tailed and tailless monads are engraved at D, which figures may be compared with the spermatozoids to the same scale on the upper part of the plate. These latter bodies have been long known, and Mr. Berkeley, in the "Micrographic Dictionary" (last edition), p. 20, says: "The bodies called cystidia or pollinaria are globular or oval cells, found associated with the basidia, containing granular matter, exhibiting molecular motion when discharged." In common with many other botanists, I am inclined to think this movement to be other than molecular, as the eddy clearly seen round the revolving bodies indicates the presence of cilia. It is impossible to believe that *life* can spring from *no-life*, the mere molecular movement of lifeless particles must be of a totally different nature from the life-movements of spermatozoids and infusoria. The revolving bodies might be referred to Micrococcus, one of the Sphærobacteria, but it must be remembered that they are the differentiated contents of the cystidia. It may be answered that if the mycelial threads of fungi will break up into true Bacteria, why may not the cell contents reappear as one of the Sphærobacteria? The question then arises, What is the nature of the obscure bodies referred to Bacteria? Are Dr. Eidam's spermatia no other than Bacteria? they are sufficiently like Bacteria. Are certain so-called Bacteria and antherozoids of some cryptogams one and the same? When once produced they are both very persistent, and they are both produced under somewhat similar conditions. The spermatozoids of Agarics only appear as the fungus has just passed maturity, and as decomposition is setting in; and as soon as the spermatozoids are set free, then the material from which they spring has vanished.

It is just worthy of note that certain spermatozoids and bacteria resemble each other in size and external form, that they are alike in being furnished with flagella or cilia, that they are produced at a time when decomposition is just setting in, and that they are seen in semi-milky fluids. The spherical bodies, when they become attached to the spores, or even threads, rupture at one end and discharge a fine thread, as at E, where they are shown germinating in a free state, which is no uncommon occurrence. Vibriones are shown at F; these bodies, with the bacteria, shown at G and H, are well known to all microscopists, and it has appeared to me that they are mere differentiated states of the old cells of the fungus which have broken up and (as a collection of cells) totally disappeared. The dotted lines indicate the movements of the bodies, whether straight, zigzag, or revolving like a wheel.

Whether the fertilised spores are able to withstand great vicissitudes of temperature and still not lose their vitality is unknown, but if other living atoms are able to live in boiling fluids, or be frozen and still live, it should be a matter of no surprise to find fungus-spores passing unscathed through similar ordeals. It is reasonable enough to imagine life to be maintained under extraordinary conditions, but to me most unreasonable to imagine life to spring from that which is without life.

As the cells of decomposing fungi disappear, various infusoria at the same time swarm into being and take the place of the collapsed cells. On violently boiling these infusoria in test-tubes along with fragments of putrid fungi, for five minutes, and sealing at the highest point of ebullition, I find the infusoria, after one or two or three months, to be still alive. During this time putrefaction is arrested in the test-tubes, the decayed fragments of fungi remain the same, and the infusoria remain inert. On opening the flasks the infusoria are at first motionless, and life is apparently at a low ebb, but the individual infusoria, as watched under the microscope, rapidly regain their accustomed activity, and in a few hours are as full of life as if they had never been boiled. The decomposing fragments of fungi now rapidly give the fluid an offensive odour.

Whilst able to resist the heat of boiling-point, these same infusoria are equally well able to resist cold, for during the frosts of the past month I froze decoctions of fungi containing infusoria into solid blocks of ice for a whole week. On thawing, after this time the bacteria, vibriones, monads, &c. were as full of life as before freezing.

EXPLANATION OF PLATE CXXXII.

FIG. 1. Vertical section through gills and stem of Agaricus (*Hypholoma*) lacrymabundus (Fr.). E, Veil. F, drops on gill. G, drops on upper part of stem, natural size.

FIG. 2. Vertical transverse section through edge of gill, with drops *in situ*. Enlarged 100 diameters. A, Trama. B, Cells forming Hymenium. C, Cystidium. D, Basidium. H, lowermost drop, containing cystidia and spores.

FIG. 3. Cells of Hymenium. C, Cystidia, containing spermatozoids. D, Basidia, with spores attached, and triangular flat crystals from the juices of the plant. Enlarged 500 diameters.

FIG. 4. Spore unpierced by spermatozoids, enlarged 3,000 diameters.

FIG. 5. Spore pierced by spermatozoids, from a drop which had dried on the surface of the Hymenium. Enlarged 3,000 diameters.

REVIEWS.

THE PHYSIOLOGICAL LABORATORY.*

THE progress of the study of Biology which has been made in this country during the past ten years is indeed vast, and it is, we should suppose, to a certain extent due to the various text-books that have been published and popular lectures that have been delivered, as well as to the movements made by the Universities, and the Government through South Kensington, that such a happy result has been achieved. But much as has been done, we fancy that the future looks brighter than ever, for we do not think we shall exaggerate its importance when we assert that the book which has been issued by Professor Huxley will do more to spread a general taste for biological pursuits than anything that has heretofore been published. For though the system described is of course that which has been followed in Professor Huxley's laboratory, yet we must remember, firstly, that in order to have access to that fountain-head the student must necessarily be living in London; and secondly, that even if he were a townsman, and a young one, he would have the extreme difficulty of surmounting those narrow prejudices which have been raised against liberal teaching by distinguished members both of the Churches of England and Rome. For it is idle to pretend that the discouragement which these two Churches have offered to free and non-sectarian scientific teaching have not been attended by the most injurious results. And it must be openly confessed, that great as has been the success of the admirable system of teaching carried out at South Kensington, it has not had that full and complete measure of beneficial results which would have accrued had it not been distinctly, if not overtly, opposed by the two sections of the religious world to whom we have already referred. It is, therefore, for these reasons that we believe that a book like that now published will do much toward the spread of natural science—and not mere bookworm cramming—for it will enable anyone who masters its details to say that he has got no inconsiderable knowledge of the science of Biology. We do not know why Professor Huxley did not issue the book with his own name alone upon the title-page, for we are sure that most of the work is from his pen. But, be

* "A Course of Practical Instruction on Elementary Biology." By T. H. Huxley, LL.D., Sec. R.S.; assisted by H. N. Martin, B.A., M.B., &c. London: Macmillan & Co. 1875.

that as it may, it is without doubt a piece of work novel in its kind and thoroughly well executed, and withal it is a work which cannot fail to make the space in the laboratory at South Kensington more sought after than ever.

And what is the plan of this book, it will be inquired? It is simply that which anyone who has gone through a little elementary course of training can readily master. It is constructed on a plan entirely *sui generis*, and it is intended to give the reader who works with it an accurate insight into Biology generally. Therefore it is, of course, a work which deals with both Vegetable and Animal life. It is divided into thirteen chapters, in each of which is discussed the following subjects, and the last section of each chapter is devoted to what is termed Laboratory work—*i.e.* to certain observations and experiments tried upon the animal or plant under examination, in order to make out practically its structures and functions. The first of these is on Yeast, which is dealt with very fully and very practically; and then follow the other subjects: Protococcus, Amœba, Blood-globule, Bacteria, Penicillium, Mucor, Stoneworts, the Bracken fern, the Bean-plant, the Bell-animalcule, the Hydra, the Fresh-water Mussel, the Fresh-water Crayfish, the Lobster, and last, but by no means least, the Frog. Very naturally the author has dealt more fully with the amphibian than any other animal or plant, because it is the only vertebrate animal dealt with in the book, and it is universally abundant, and is so easily chloroformed and then "pithed," so that pain is thus completely prevented. The preceding animals and plants occupy 151 pages of the book, while the frog takes up the remainder of the volume, minus three pages; that is to say, 106 pages are devoted to its descriptive anatomy, which is minutely dealt with. In fact, there is an elaborate account of the general anatomy of the frog, which is completely dissected, including its brain, nerves, muscles, and vascular tissues. And further, the author treats not only of the structure of the animal so far as it may be followed by the naked eye, but he deals also most fully with its microscopic anatomy, and, in this instance as in all the others, makes the laboratory work follow the anatomical description. And both of these sections are dealt with as those familiar with Professor Huxley's work can readily imagine for themselves. Whether it is the examination of the blood, or the preparation of the vascular system for dissection, or the method of cutting in order to expose the brain or the eye, or the best mode of going to work with a view to properly examine the epithelium, or, finally, the practical teaching in reference to the physiological properties of muscle and nerve, in all these we recognise at once the practical skill as well as the scientific knowledge of a master-mind.

Throughout the other part of the book we observe the same thoroughly practised hand in the working of the several sections. This is what is so valuable to the student, as, for example, when there are given those hints as to the use of osmic acid solution in dealing with the Infusoria, the best mode of killing the hydra, the guarding the bristle with wax, the examination of the circulatory apparatus in the lobster, &c. &c., all of which point to the decidedly practical form of the work. We are glad to notice too that in speaking of magnifying powers he uses the definite expressions $\frac{1}{2}$ or $\frac{1}{4}$ or $\frac{1}{8}$ of an inch objective, and that there are only one or two instances in which the foreign method of designation, such as No. 7 or 8, is employed.

We are sure that English microscopists will be very grateful to Professor Huxley for having made a stand against the absurd method of nomenclature now adopted by many of our histological writers. We suppose it would have been impossible to introduce woodcuts into such a volume as the present one, although it would be of undoubted importance to the student who is ignorant of the different forms he is looking for. However, we may, in concluding this imperfect notice of a very important volume, express our thanks to the two gentlemen—Professor Huxley and Dr. Martin—who have laboured so well for our advantage.

CLIMBING PLANTS.*

ALTHOUGH this book is called a second edition it is really, so far as the general public is concerned, the first time that the work has been issued. It is true that it was first published in the "Journal of the Linnean Society," but then such publication merely supplies the book to the Fellows of that Society, whilst in its present form it is "comeatable" by the whole world. It certainly appears to us a wonder that Mr. Darwin should have kept such an important light under the bushel of a Society's publications, and that, too, for so long a period. However, now that he has given us the work in a clearer form, with additional facts, and with the few but clever engravings from drawings by his son, George Darwin, we have only to thank him, as we have always done, for the importance of his labours. The present book has an especial value over the earlier edition, in that it takes up the point which has been so ably discussed by Professor Sachs in his recently translated "Text-book of Botany," of the cause of the motion of tendrils. It is remarkable, too, that Mr. Darwin differs from Professor Sachs as to the cause of certain movements of the tendril, and in this it appears to us that there is much that is reasonable in Mr. Darwin's view. This, indeed, is the most interesting, because the most novel, part of the book. "Sachs," he says, "attributes all the movements of tendrils to rapid growth on the side opposite to that which becomes concave. These movements consist of revolving nutation, the bending to and from the light and in opposition to gravity, those caused by a touch and spiral contraction. It is rash to differ from so great an authority, but I cannot believe that one at least of these movements—curvature from a touch—is thus caused. In the first place, it may be remarked that the movement of nutation differs from that due to a touch, in so far that in some cases the two powers are acquired by the same tendril at different periods of growth; and the sensitive part of the tendril does not appear capable of nutation. One of my chief reasons for doubting whether the curvature from a touch is the result of growth is the extraordinary rapidity of the movement. I have seen the extremity of a tendril of *Passiflora gracilis* after being touched distinctly bent in 25 seconds, and often in 30 seconds; and so it is with the thicker

* "The Movements and Habits of Climbing Plants." By Charles Darwin, M.A., F.R.S., &c. 2nd edition, revised, with illustrations. London: John Murray. 1875.

tendril of *Sicyos*. It appears hardly credible that their outer surfaces could have actually grown in length, which implies a permanent modification of structure, in so short a time. The growth, moreover, on this view must be considerable, for if the touch has been at all rough the extremity is curled in two or three minutes into a spire of several turns." It must be at once confessed that in regard to this question the probability of the argument lies on Mr. Darwin's side. For it is utterly impossible to suppose that any development of tissue could occur in so short a period of time. But this is only one point of interest in the work before us, which contains many. For example, there is the curious fact that a climbing rose will ascend the walls of a house if covered with trellis, without there being any explanation of the fact. Mr. Darwin says:—"How this is effected I know not; for the young shoots of one such rose when placed in a pot in a window bent irregularly towards the light during the day and from the light during the night, like the shoots of any common plant; so that it is not easy to understand how they could have got under a trellis close to the wall." And we do not see that Professor Asa Gray has done very much to help us on this point, though Mr. Darwin thinks he has. Indeed, we are very much disposed to consider that the tendency of certain climbing plants to creep along and to show an apparent knowledge of the parts on which they are growing is only to be explained by assuming the possession by plants of certain powers that have been hitherto allowed by Biologists to exist in animals alone. And we think that anyone who carefully reads this book will see that it is utterly impossible to explain certain motions of plants by the ordinary rules of botanists. We should have liked to quote the author's summary on this very important point, but as we cannot, we would especially direct our readers' attention to page 202, and that of succeeding paragraphs. We cannot do better than conclude our notice of this excellent book with the following quotation:—"We see how high in the scale of organisation a plant may rise when we look at one of the more perfect tendril-bearers. It first places its tendrils ready for action as a polypus places its tentacula. If the tendril be displaced it is acted on by the force of gravity and rights itself. It is acted on by the light and bends towards or from it, or disregards it, whichever may be most advantageous. During several days the tendrils or internodes, or both, spontaneously revolve with a steady motion. The tendril strikes some object, and quickly curls round and firmly grasps it. In the course of some hours it contracts into a spire dragging up the stem, and forming an excellent spring. All movements now cease. By growth the tissues soon become wonderfully strong and durable. The tendril has done its work, and has done it in an admirable manner."

THE DAWN OF LIFE.*

IN the above work Dr. Dawson has laid before us, in a clear and able manner, his views, and of those also who coincide with him, as to the nature of a remarkable fossil structure found in the ancient Laurentian

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* "The Dawn of Life." By J. W. Dawson, LL.D., F.R.S. London, 1875.

rocks of Canada, the *Eozoon*, the origin of which has caused some difference of opinion, and produced a crop of descriptive and controversial, but for the most part technical literature, as to whether the structure was organic and foraminiferal, or the result of chemical and mineral metamorphism. The object of the book is therefore to give a popular account of what is known as to the organic structure of the Dawn-animal, stating the substance of all that has been previously published, and including many new facts illustrative of points hitherto more or less obscure. The matter is arranged under the following heads: a notice of the Laurentian formation itself; the history of the discovery and proper interpretation of the fossil; the description of the Eozoon and its mode of preservation, its contemporaries and immediate successors, or those allied to it by zoological affinity, and also the objections which have been urged against its organic nature. The lower and upper Laurentian rocks are 30,000 feet in thickness, and the Eozoon occurs in the lower; the upper series and the overlying Huronian being unfossiliferous, and together with the lower were termed the Azoic, from the supposed absence of all living things. Hence the interest in the discovery of the presumed dawn of life in the oldest of all the formations known to the geologist, and more thoroughly altered or metamorphosed by heat and heated moisture than any others. Under the head, What is Eozoon? Dr. Dawson enters into a full description of the structural characters of this form and their relation to other Foraminifera, and gives the corroborative opinions of other authors. "Its relation to modern animals of its type has been very clearly defined by Dr. Carpenter. In the structure of its proper wall and its fine parallel perforations it resembles the *Nummulites* and their allies; and the animal may be regarded as an aberrant member of the Nummuline group, which affords some of the largest and most widely distributed of the fossil Foraminifera."

The objections to the animal nature of Eozoon are fairly discussed, and of the three general modes for accounting for its existence, first that of Professors King and Rowney, who regard the chambers and canals filled with serpentine as arising from the erosion or partial dissolving away of the serpentine and its replacement by calcite; and secondly, that Eozoon forms are merely peculiar concretions; both of these are considered not conclusive. The third theory, that of filling of cavities by infiltration with serpentine, accords with the fact that such infiltration by minerals akin to serpentine occurs in fossils in later rocks, and thus explains to some extent the condition of Eozoon.

We may commend the book, with the excellent illustrations and descriptions, to the careful perusal of those who are interested in the character and real nature of the first presumed traces of organic life in the history of the earth, so as to understand the strong grounds upon which Dr. Dawson and the able naturalists who support his view regard the Eozoon as the oldest known Protozoon and related to the Nummulinidæ. On the other hand, the opponents of the organic character of the Eozoon have, from their point of view, given reasons for inferring that the nummuline-like structure may be the result of the aggregation and rearrangement of mineral matter due to chemical and metamorphic action; for it must not be forgotten, as the author states, that the appreciation of the evidence for such a fossil as

Eozoon requires an amount of knowledge of minerals, of the more humble types of animals, and of the condition of the mineralization of organic remains.

RELIQUIÆ AQUITANICÆ—Concluding Part.*

IT was in the same month as that in which the present notice is written, and in the year 1865, that the first part of this splendid essay made its appearance. And now, in the last portion of the year 1875, the final "part" appears. In ten years how many mighty changes have taken place! The two great leaders of Geological Science have within that period gone to their last resting-place, and the two distinguished men—M. E. Lartet and Mr. Christy—whose names appear on the title-page of this work have likewise rendered their account to Heaven. The volume, therefore, although it is a very valuable one, is by no means the sort of work that Mr. Christy or M. Lartet would have made it had they lived. Indeed, if we have a fault to find, it is with the want of connection which exists between the different portions of the volume. It partakes more of the character of a journal to which different men contribute without the least regard to each other's writings, than anything else. It wants the connecting link which would surely have been presented had either of the original authors been in existence. How can it be otherwise when we have thrown together papers by Prof. Rupert Jones, M. Louis Lartet, Dr. Pruner Bey, M. de Quatrefages, Mr. J. Evans, Mr. A. C. Anderson, Mr. L. Austen, Dr. Sauvage, Dr. A. Milne Edwards, Dr. E. Harvey, and Mr. T. G. B. Lloyd, together with a few of the original authors' essays? The reader may at first sight consider that the editor is to blame for this. But in consideration of the statements he has put forward, we at once perceive that he is perfectly free from censure. He says the "mammalian remains are still undescribed, for M. Lartet's notes were left in too fragmentary and unfinished a state to yield a continuous memoir, and no other palæontologist as yet has turned his attention to the subject." However, even admitting this loss, we must confess that a tolerably good account of the people who lived in this period may be gleaned from the various descriptions given; and we may admit the editor's assertion that the features, stature, character, and race of the cave-dwellers in this portion of the globe have been fully detailed. "Their habits have been elucidated in the descriptions of their weapons and other implements adapted for shooting or darting, stabbing, clubbing, cutting, chopping, scraping, boring, drilling, and other work wanted in either peace or war; in hunting or fishing, in domestic operations; and in designing the works of art which so markedly characterised this peculiar people of Western Europe. Their cooking stoves, hearths, and mortars; their bodkins and sewing needles; their personal ornaments and amulets, perforated for stringing; their

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* "Reliquiæ Aquitanicæ; being contributions to the Archæology and Palæontology of Perigord and the adjoining Provinces of Southern France." By E. Lartet and Henry Christy. Edited by T. R. Jones, F.R.S., F.G.S. London: Williams and Norgate. Nov. 1875.

whistling instruments and their batons, possibly distinctive of rank and dignity—have received much attention. . . . Even their owner-marks, tally-scores, and probable gambling tools have been recognised and described. How they made their many implements of flint, and why that stone was good for their purposes, has also been explained." Indeed, not an insignificant feature of the book is the contrast that has been made by some of the writers between the implements found in these French caverns and the various forms that are employed by several savages even of the present day. Two essays, which constitute the bulk of the present "part," are those of "Fossil Man from La Madelaine," and on "The Reindeer of Newfoundland." They are exceedingly well illustrated, and though short are to the point. As to the engravings, we have almost always spoken highly of their execution. Those in the present part are merely woodcuts, but all of the plates, except one or two that were executed in England, are simply admirable in all respects. In conclusion, we must not forget that a word is due to the executors, who have spared no expense in bringing their brothers' intended design to completion. We think that the public owe them sincere thanks for their labours, and in selecting Professor Rupert Jones as editor they could not have better supplied a guiding hand.

RELIGION AND SCIENCE.*

HERE we have a book written by a Rector upon the reconciliation of Science and Religion, and at the outset we must confess that it is written in so fair and honest a spirit that it seems to us more detrimental than conservative to religious views. The author has attempted to reconcile the present condition of science to his own exalted type of Christianity, and in doing so he has not used a syllable that can in the slightest way offend the man of science. Indeed, he has gone so far in his admissions that it strikes us very forcibly that to a real student of science it is a book which would go far to alter his Christianity, if it already existed. Mr. Gibson has made himself acquainted with all that men of the type of Mr. Darwin, Professor Huxley, Mr. Mill, Sir W. Thomson, Sir J. Lubbock, Sir W. Hamilton, Professor Max Müller, Sir Charles Lyell,—not to speak of Paley and many other older authorities,—have written; and he himself comes down from the standard that would be alone accepted by most conservative churchmen, and in giving up Paley's doctrine of adaptation to special ends, and acknowledging Mr. Darwin's view of Natural Selection, he endeavours to show that he is right in the assumption that if a Deity in the ordinary sense of the word does not exist, there is nevertheless such a being as is immensely superior to man's organisation and who will not look on him in judgment in a Pharisaic spirit, but will prove to be considerate and kind. His argument is, it seems to us, wordy and diffuse, and while it will certainly

* "Religion and Science, their relation to each other at the present day." Three Essays on the grounds of religious belief, by Stanley T. Gibson, B.D., Rector of Sandon, in Essex. London: Longmans. 1875.

not satisfy the unbelieving man of science it will very probably give the "first shake" to the opinions of those who have gone through life with their religious faith in one hand and their scientific belief in the other. But while we object to the space over which Mr. Gibson has taken us, we confess that we have been enlightened on many points in our journey together, and we thank him heartily for the extreme courtesy he has invariably exhibited. To show that the author is one who has clearly a scientific mind the reader need only refer to the following passage in which he alludes to a not infrequent habit even among scientific men:—

"They talk sometimes of tracing things back to their nebulæ, as though they were thus obtaining a comprehensive view of the entire history of creation. But supposing that the solar system did originate from a nebula, have they a right to assume this development to be coeval with the universe? We have good reason to think that stars are by no means of equal antiquity, and that our own sun is not one of the oldest. Further, that nebula out of which it sprung need not be thought the primitive state of matter. It might have been the result of some previous condition of things, say a collision of two great cosmical bodies and the vaporising of their masses."

There is another paragraph we should like to have inserted, as it shows the broad views of the author. It is that in which he takes to task Professor Birks for his assertion in the Scripture doctrine of creation that "if there never was a beginning of time the present moment could never have arrived." There are many points in the argument which the present writer would wish to dwell on, but that space forbids. He therefore bids, he hopes, *au revoir* and not *adieu* to Mr. Gibson, and thinks he has with the worst materials at command made out a most excellent brief in the present case.

POPULAR OPTICS.*

WE are sorry to be compelled once again to find fault with one of Messrs. King's handbooks, the more so as we feel assured that that eminent firm has nothing whatever to do with the work under notice further than their labours as publishers, which are performed in a most thoroughly satisfactory manner. In its mere mechanical details the work is capitally done: no fault can be found with either the printing or illustrations of the book before us. But as a popular essay on a most interesting branch of optics, it is the most incomplete work that we have for a long time met with. The author seems to be devoid of that power of popularising his subject which is possessed in so marvellous a manner by our own Tyndall. And he has added to the difficulty by endeavouring to introduce elementary mathematics. Further, his descriptions are extremely incomplete in nearly every instance. Take, for example, what he has to say on the microscope as

* "The Nature of Light, with a general account of Physical Optics." By Dr. E. Lommel, Professor of Physics in the University at Erlangen. With 188 illustrations, &c. Henry S. King & Co. 1875.

an illustration. In this he introduces us in about a page and a half to one of the foreign instruments, and he absolutely dismisses the subject without any allusion to the two lenses of the eye-piece, or even in the most rudimentary shape or form to errors of chromatic or spherical abberration, or to the fact that there is such a condition as that of immersion in object-glasses. His observations on the subject of the spectroscope are wrapped in the same Cimmerian darkness. And his idea that the spectroscope may "render important service to physiology and forensic medicine," by the fact that poisoning by hydrocyanic acid may be immediately recognised by it, is of course absurd, because the blood would never be examined until all trace of the poison had passed away. We have no doubt that the author is a thoroughly competent authority, but we are equally certain that he is not a populariser of science, and we therefore regret that he has been employed by Messrs. King, to some of whose books of this series we have given the very highest praise. We shall be much surprised indeed if it ever achieves popularity among our English readers.

ZOOLOGY FOR JUNIORS.*

WE fancy that we spoke well of this book when it appeared in its first edition. If so our praise was given where it was due, as the passage of the work through a second issue pretty conclusively demonstrates. It is a book well and clearly written and very well illustrated—more than 150 woodcuts—and the author has very properly placed the name of the writer from whose works he has taken the illustrations after all woodcuts, except those which have been in service for the past thirty years. Thus we notice cuts from Huxley, Forbes, Johnston, Gosse, Hincks, Ehrenberg, Schmidt, Müller, Carpenter, Carter, Beale, Günther, Dümeril, Van der Hœven, Woodward and others, showing that he has been careful to select from good authorities; and the matter of the book is fairly compiled and many additions have been made to the Vertebrata, so that we can congratulate the author on the success of his book, which of course is an elementary one.

TAPE-WORMS.†

THIS is a book to which is hardly due a place in this Review, for it really is a medical work. Still, it treats upon a subject of which the author is the first scientific exponent in this country, and therefore it

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* "An Introductory Text-book of Zoology for the use of Junior Classes." By H. Alleyne Nicholson, M.D., D.S.c., M.A., Professor of Natural History in the University of St. Andrews. 2nd edition. Blackwood and Sons: Edinburgh, 1875.

† "Tape-worms. Their Sources, Varieties, and Treatment; with one hundred cases." By T. Spencer Cobbold, M.D., F.R.S. 3rd edition. London: Longmans. 1875.

may partly lay claim to a word or two. Dr. Cobbold has dealt with the subject of tape-worms and their treatment, and he has nearly 100 cases in which he records almost invariable success. In most of these cases the common male fern was the remedy successfully employed, and we think that if the prescriber is cautious in obtaining a proper sample of his drug, his results with this medicine are likely to be good. However, there are some instances in which the worm cannot be removed. The writer of the present notice remembers two cases which were under his own treatment—one for more than three months—and which he was compelled to send away uncured. They had both been in India, had been under the care of military medical men and "club doctors," and one of them had spent some weeks at Netley Hospital,—and yet they were not cured. This little book gives sensible advice to the medical man—advice not always, we are sorry to say, followed,—and we are glad to see it in its third edition.

SCIENCE BY-WAYS.*

IN this volume Mr. Proctor has expressed his wrath with certain critics, more especially those of the American school, and we think there is much justice in his remarks. Mr. Proctor has been blamed for writing popular treatises, and we cannot at all see for what reason people who are not his immediate friends can object. There is not the slightest doubt that he wields a clever pen, and in addition to this he comes before the public with exact knowledge and with a power of popularising a subject which very few possess under such circumstances; then who can object to his writing as many works as he pleases to issue? We certainly do not see what right critics have to cavil. They have to review a book like that before us at this moment, which possesses intrinsic worth, which popularises in a telling manner, and yet without any slovenliness as regards its scientific value. Why, then, can they not do their work without attacking the author? We cannot tell, unless it be that private pique prevents them. For ourselves we only regret that one who possesses the unquestioned ability of Mr. Proctor should expend his time in popular essay-writing rather than in noting down the observations made with the telescope or the spectroscope. But we hail with pleasure the announcement of the issue of a new work from his pen. In the present book we have a reprint of a series of essays, most of them astronomical, but one or two physiological, and indeed to our mind these are the most interesting of the whole assemblage. It deals with "life past and future in other worlds," the planets put in Leverrier's balance, comets' tails, three orders of comets, the sun a bubble, the sun's surroundings and future eclipses, the weather and the sun, finding the way at sea, journeys towards the North Pole, rain, damage from lightning, growth and decay of mind, have we two brains? on some strange mental feats, automatic chess

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* "Science By-ways, &c. &c.; to which is appended an Essay entitled 'Money for Science.'" By R. A. Proctor, B.A., &c. London: Smith & Elder. 1875.

and card playing, and last, but by no means least in importance, money for science, a brilliant essay which appeared, if we mistake not, in the "Contemporary Review." All of these several chapters are of interest, but that on "Have we two Brains?" strikes us as of especial importance. We remember reading the report of Brown-Sequard's lecture on the subject, which has formed the basis of Mr. Proctor's chapter; but it was so exceedingly badly reported that we could make nothing of it as a physiological argument. We have read Mr. Proctor's pages on this subject with great interest, therefore; and while we differ from him on some points we agree with him on others; and we would especially commend his mode of dealing with the question to our readers. All through his book is of more than general interest and value.

POPULAR CONCHOLOGY.*

ONE would have thought that the ordinary British Mollusca of our ponds, streams, and groves had been described enough. However, there is, we suppose, still room for a good cheap popular description, with fairly coloured plates; and such a book is that before us, by Mr. J. E. Harting. The present work is an enlarged reprint from the "Field" newspaper, and it deals with the subject in such a manner that any person of ordinary intelligence can identify the species described. The author has adopted the plan of grouping the shells according to the soils which they inhabit, thus giving the reader an opportunity of finding a number of specimens on each excursion. We think the idea is good for a popular book of the kind. The volume has had the advantage of the revision of the late Dr. J. E. Gray, F.R.S., and it is one we can commend.

WHAT IS AIR?†

ONE who did not understand chemistry would hardly comprehend how it was that a whole book was required to answer the question in the above heading. Yet so it is, and Mr. W. N. Hartley has given us a very excellent and scientific, yet popular account of air in the 243 pages which form this volume. It is, in fact, but a species of report of his lectures, which were last year (1874) delivered before the Royal Institution, on the subject of Air in its relation to Life. However, the author has doubtless expanded many of the points he referred to in his discourses,

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* "Rambles in Search of Shells, Land and Fresh Water." By James E. Harting, F.L.S., F.Z.S. With coloured illustrations. Van Voorst. 1875.

† "Air, and its relation to Life; being, with some additions, the substance of a Course of Lectures delivered at the Royal Institution in the year 1874, by W. N. Hartley, F.C.S." London: Longmans. 1875.

and he has added a number of illustrations—more than 60—which give more interest to the volume. The greater part of the volume is familiar enough, but the latter part is of peculiar interest, because it contains an ample and clear account of M. Pasteur's experiments on air and fungus-spores, &c.; and it shows the error of Dr. Bastian's processes, though in some cases there is rather too much of opposition displayed to leave the reader perfectly satisfied on this point. The concluding observations which the author makes on the subjects of putrefaction and decay are full of interest, and might we think with advantage have been much extended. The truth is shown of Pasteur's saying, that "Fermentation, putrefaction, and slow combustion are the three natural phenomena which concur in the grand operation of the destruction of organised matter, a necessary condition of the perpetuity of life on the earth's surface."

THE UNIVERSE.*

IN speaking of this splendid work as it appeared in its first edition we gave the highest praise to the author for the ability displayed in carrying out his scheme, and to the publishers for the lavishness of illustrations with which they presented the volume to the public. In noticing the present edition—the third—we have little more to do than to say that it is issued at a much cheaper rate of sale than its predecessors, while it has not suffered any serious loss by the omission of a few of the illustrations and of the notes which characterised the earlier issue. It is almost needless to tell the English reader that M. Pouchet—the great supporter of the doctrine of Spontaneous Generation in France—was one of the first naturalists of the day, and he has therefore given us a book which is an unquestionably admirable introduction to the study of natural history as a whole. As he says in the preface, "I have gleaned everywhere to show that Nature affords matter for interesting observations. The animal and the vegetable worlds, the earth and the heavens, appear by turns upon the scene." Indeed, there could be no better description of the work. It treats of Nature as a whole, and in the most fascinating style—well sustained in the translation—the author has told us the history of the animal and vegetable worlds in the present and in the past, and has added some observations on the sidereal or starry system, which, though small in their extent, are nevertheless of importance. Truly, too, the artistic portion of the work has been placed in the most reliable hands.

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* "The Universe; or, the Infinitely Great and the Infinitely Little." By F. H. Pouchet, M.D., Member of the Institute of France. Third Edition. London: Blackie & Co. London, 1876.

ASTRONOMY FOR THE PEOPLE.*

MUCH as is the custom adopted of crying down the once popular books of the late Dionysius Lardner, there is no doubt that they have not yet been succeeded in many instances by books as well adapted to the mind of the people. And indeed we know of few cases in which books on Astronomical Science appeal so truly to the public, as in the present instance. Mr. Edward Dunkin, Sec. R.A.S., has been the editor selected for the present volume of Dr. Lardner's series of books on Natural Philosophy, and we can say—as of course was to be expected—that he has done his work with conscientiousness and clearness. The present edition was published early in October last, and Mr. Dunkin has added to Chapter XV. planets 147 and 148, the last of which—which, by the way, is not now the last—was discovered Aug. 7, 1875. One of the features of the present edition is that the elements of the orbits of all the planets are given, being arranged in the order of the distances of the planets from the sun. It is elaborately illustrated; besides more than 100 woodcuts, there are thirty-seven admirably executed plates of the different heavenly bodies, telescopes, &c. Besides this is a copy of Beer and Mädler's map of the moon, and, we are almost pleased to say, no spectroscopic plates at all. It will be found a book worthy of being read by the class for whom it is intended.

SHORT NOTICES.

Lecture on the Geology of Croydon, in relation to the Geology of the London Basin and other localities. By J. Morris, F.G.S. The "Chronicle" Office, Croydon. 1875.—This is the publication of a lecture delivered by Professor Morris before the Croydon Microscopical Club, and though it has so humble an origin, it is not on that account to be classed with literature of this order. It is really a most valuable addition to our geological history of the London Basin, and we trust that the Professor had a number of copies struck off, for we are sure that the demand for the work will be considerable when it is known of. There are very few, if any, of our English geologists whose knowledge of the strata, both geologically and palæontologically, equals that of the author of this lecture; and he has given us in a pamphlet of about 27 pages, accompanied by an admirable coloured map and section, and several woodcuts of the district, a discourse in which he discusses the origin of those various beds and their fossils, and deals with the several elements of the London Basin. It would be impossible to follow the author in a sketch like this; but we must mention that he traces out the whole series of deposits from the chalk upwards, and he adds considerably to the interest of his paper by his marking out the beds which occur in Paris and Belgium, and are consi-

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* "Handbook of Astronomy." By D. Lardner, LL.D. Fourth Edition. By Edwin Dunkin, Secretary to the Royal Astronomical Society. London: Lockwood & Co., 1875.

dered to be the representatives of our London deposits. By far the most interesting parts of the paper are the notes, which we presume were afterwards added. For in these, which are nearly as extensive as the text, the author gives us the opinions of Dr. Hayden and Professors Lesquereux and Cope in reference to the singular want of nonconformity which exists between the cretaceous and succeeding strata, and alludes to the fact that, in reference to the chalk and the tertiary flora, a complete "uninterrupted succession of life" took place. In his remarks, too, on the London clay, we find an abundant reference to the numerous and diversified fossils, animals and plants, of the period, the immense number of turtles (no less than ten species being represented in the clay of Sheppy) giving the Professor the opportunity of a joke *à propos* of our civic authorities. One of the most important points of the lecture is the table at the end, which shows us at a glance the formations from the cretaceous to the recent alluvium, which are present or absent from the London Basin (at Croydon, London, and Hants) and the Belgian and French corresponding deposits. The London geologist should be grateful to Professor Morris for the task he has undertaken.

Time and Time-tellers. By James W. Benson. London: R. Hardwicke. 1875.—This little book, although it is doubtless issued with the object of being a trade publication, is nevertheless a very interesting work for those who care for a chatty, gossiping account of the history of clocks and watches from the earliest device down to the period of Benson's great clock which was exhibited at the International Exhibition of 1862. The history is well written and fairly stated, and the explanation is given of the several parts of a watch or clock which have been from time to time added as improvements. Finally, there is a useful table at the end of the work of the equation of time, by means of which, with an ordinary sundial, one may readily calculate the exact time for himself.

SCIENTIFIC SUMMARY.

[*The Editor feels that he must apologise to his readers for the extreme shortness of the various summaries in the present Number. The explanation is, that room had to be made for the articles which have—in one case especially—far outrun their usual and proper limits.*]

ASTRONOMY.

THE Sun.—According to the Astronomer Royal, the spots at present are fewer than he has ever known. Photography is being applied to them at Greenwich. A valuable series of photographs, comprising more than an entire spot-cycle of eleven years, has been presented to the Astronomical Society by the executors of Professor Selwyn. Padre Secchi has reported his observations from April 23 to June 28 to the Académie des Sciences. He had been recording, not, as formerly, the number, but the area of the spots, which were steadily diminishing, as well as the daily number of protuberances. The more vigorous eruptions ceased as the larger spots disappeared; lofty protuberances had become very rare; those at the pole had greatly decreased; and the faculæ which had formed polar coronæ had vanished; so that on the whole we may be passing through a *minimum* of these phenomena.

The Moon.—The remarkable flattenings of the limb to which the Rev. H. C. Key drew attention twelve years ago were re-observed on Nov. 11 or 12, to great advantage, by himself, Messrs. Birt, With, and Erck. Mr. Key says that if these two depressions had been repeated all round the limb its form would have been a very decided dodecahedron. The suitable libration had been previously computed by Mr. Marth, but as Mr. With had seen them even more strikingly during the previous lunation, it is evident that they are worth looking for at other epochs. Their interest arises from the fact that they cannot be the profile exhibitions of great plains, which would still preserve the general convexity of outline, but must have the effect of concavities as respects the centre of the moon; resembling nothing, at least of any magnitude, in the visible hemisphere: an indication, perhaps, that the formations at the back of the moon may not be entirely similar to those on this side.

Mars.—Dr. Terby, of Louvain, is actively occupied in collecting observations and drawings of this planet. The Observatory at Leyden has purchased the "Areographische Fragmente" in two MS. volumes, left unpublished by Schröter. Kononewitsch suspects a diminution of the planet's brightness. The Astronomer Royal has pointed out the importance

of a renewed investigation of the solar parallax from the opposition of Mars in 1877, which he considers preferable to the transits of Venus, and will publish in the Monthly Notices a chart of the stars to be observed with the planet at that epoch.

The Minor Planets.—Discoveries in this region have been increasing in an unprecedented ratio. No. 150 was detected, Oct. 10, by Watson at Ann Arbor.—No. 151 by Palisa at Pola (on the Adriatic), Nov. 1.—No. 152 by Paul Henry at Paris, Nov. 2.—No. 153 by Palisa, Nov. 12.—No. 154 by Prosper Henry at Paris, Nov. 6.—No. 155 by Palisa, Nov. 8.—No. 156 by Palisa, Nov. 22. (These numbers are not in order of priority, and probably will have to be rectified.) So rapid a development of our knowledge in this direction, amounting to sixteen during the present year, and six in one month, is likely to cause embarrassment. Computation already begins to be uncertain, and failures frequent in rediscovery.

Jupiter.—M. Flammarion, who has been drawing this planet, has noticed various remarkable changes in the colour of the luminous zones, and a number of white elliptic spots, seemingly followed by ill-defined shadows, and terminating in angular trains, as if the shadow passed through separate strata of clouds.—Miss Hirst, of Auckland, New Zealand, has sent to the Royal Astronomical Society some drawings made with an $8\frac{1}{2}$-inch silvered glass Browning reflector during the opposition of 1875. On one occasion a number of small dark spots with extremely black centres were seen on the S. polar zone; at another time a small oval patch of a decided sea-green for three days near the same pole. Lassell's bright spots were twice observed. It is evident from these and other observations that we are at present far from having attained any consistent interpretation of the phenomena of this colossal planet; and the want of consent among contemporary drawings points to the conclusion that something better must be accomplished in this way before we can make satisfactory progress. The inscription must be more faithfully copied before we can attempt to read it; and probably this will not be done excepting in the use of those commanding instruments, now fortunately becoming more common, in which the size and brightness of the picture will diminish the ratio of personal equation to a much more unimportant fraction than that which now represents it. Dr. Terby may, we hope, be induced to repeat on this most interesting planet the investigation which he has so ably and diligently conducted in the case of Mars. —Le Verrier has investigated the mass afresh, and adopts $\frac{1}{1046{\cdot}77}$, the value given by Airy from observations of the fourth satellite in 1835. This would of course be preferable to the old result, $\frac{1}{1067{\cdot}09}$, obtained by Laplace from Pound's observations; but he finds it superior also to Bouvard's (1824) of $\frac{1}{1070{\cdot}5}$, deduced from the perturbations of Saturn by a method which he discovers to be inexact, but which accidentally led to nearly the same value as Pound's. From Triesnecker's observations in 1794 and 1795, Bessel had brought out $\frac{1}{1055{\cdot}68}$; Nicolai, from fifteen oppositions of Juno, $\frac{1}{1053{\cdot}92}$; Encke, from fourteen oppositions of Vesta, $\frac{1}{1050{\cdot}36}$; Santini had deduced $\frac{1}{1049{\cdot}2}$; Bessel, from his own measures, $\frac{1}{1047{\cdot}879}$; Krüger, from the perturbations of Themis,

$\frac{1}{1047{\cdot}16}$; Möller, from Faye's comet, $\frac{1}{1047{\cdot}79}$; Von Asten, from that of Encke, $\frac{1}{1047{\cdot}61}$.

Saturn has been very unfavourably situated for English observers; but the position of the satellites has been compared with Marth's ephemerides by Mr. Christie at Greenwich.—Le Verrier has compared his theory of this planet with the observations of the last thirty-two years, and finds the result satisfactory, some slight discrepancies being probably due to the varying aspect of the ring.

Uranus.—Professor Newcomb, who is in charge of the great achromatic at the Washington Observatory, of 26 inches' aperture, has made a special study of the satellites of this body during the early part of this year. He fully confirms Lassell's opinion that there are only four, the orbits of which he finds nearly circular and in the same plane. The brighter satellites, *Oberon* and *Titania*, appeared in this noble instrument about equal to fourth magnitude stars with the naked eye; the two inner ones he thinks the most difficult of well-known objects, but was surprised at the precision with which he could bisect them. They were pretty certainly discovered by Lassell, and have not been, he thinks, subsequently seen by any one except himself; they are claimed, however, by the Melbourne reflector. Sir W. Herschel's outer satellites he pronounces non-existent. The feeble perturbation of these minute bodies by each other or by the far-distant sun in the immediate presence of their overpowering primary enables the mass of the latter to be ascertained with considerable exactness, and the Professor deduced a value of $\frac{1}{22600}$. The accurate focusing of the eye-piece was, however, disturbed by the differing colour of the redly illuminated micrometer webs and the greenish-yellow satellites, and this may somewhat affect the result. No markings were detected on the disc. It is believed that the two brighter satellites are within the grasp of the larger telescopes in England.

Observatories and Instruments.—The Paris Observatory is now opened by Le Verrier's orders three times a week in the evening, weather permitting, and two large telescopes are placed at the disposal of visitors provided with letters of admission, obtained by application to the secretary. This is a move of the most commendable nature, and an example which we should do well to follow. The arrangement of our public observatories might not admit, generally speaking, of such an interruption; but it might be worthy of consideration whether observatories for popular and educational purposes might not be established in our larger cities, provided with sufficient instruments and attendants, the expenses of which might be met by subscriptions and entrance charges.—We regret to find that Mr. Hind's observatory at Twickenham, the 7-inch Dollond achromatic in which did such excellent service at Mr. Bishop's in Regent's Park, is to be dismantled, and the instruments presented to the Royal Observatory at Naples.—Winnecke at Strasburg describes a new orbit-sweeper, and announces the commencement of a review of nebulæ.—The observatory of the Rev. H. C. Key, at Stretton, near Hereford, is now in a high state of efficiency, being provided with two 18-inch silvered glass specula, perfect to the edge, one of which is equatorially mounted and driven by clockwork. There is a

filar micrometer and apparatus for wire-illumination by galvanic current, and a large and ponderous spectroscope by Browning, with two prisms, of which one only can be used for very faint objects, the collimator lens and object-glass of inspecting telescope having each an aperture of 1½-inch; there is a tangent-screw micrometer, and filar ditto arranged to throw an illuminated image of the webs across a faint spectrum; besides the usual appliances of transit, clocks, &c.—Mr. Lockyer and Major Festing have been sent by the English Government to Rome, with the object of borrowing from the Italian Government a collection of interesting astronomical instruments, to be exhibited next year at South Kensington.—Mr. Lick, it is said, has selected Mount Hamilton, in Santa Clara county, California, 4,448 feet high, with no rival within fifty miles, as the site for the "million dollar telescope."—The largest achromatic ever made will shortly be in progress at Mr. Grubb's new factory near Dublin. The aperture will be 26 inches, or 27 if the discs, which are the production of M. Feil, of Paris, will admit of it. It is intended for the grand new observatory at Vienna, and will probably not be finished before 1878.—A 12¼-inch object-glass by Grubb has recently been mounted at the new Observatory at Oxford.—Feil's glass, which seems likely to supersede that of English manufacture, not now as successful as in past years, has been already tried and approved by Wray.—Alvan Clark, it is said, has received an order from the Austrian Government for an immense reflector, to be placed in a new observatory at Trieste. (For "reflector" we should probably read "achromatic," though we have heard that specula occupied the earliest attention of that great optician.)—The new great reflector at the Paris Observatory is said to turn out very satisfactorily. The movable part weighs nine tons, the speculum of silvered glass half a ton, its diameter being 120 centimetres (47¼ inches), and focal length 6·8 metres (22 ft. 4 in.) The front view has been adopted. It is said to give good definition of minute stars; though we may be pardoned for suggesting that if it was finished by the method of retouching devised by Léon Foucault, its figure is hardly likely to equal those worked by the direct process adopted by the most eminent makers in England. This magnificent instrument, which is protected, when not in use, by a gigantic iron cover, movable on rails, has been six years in construction, at an expense of 8,000*l.*, of which one quarter was absorbed in the speculum alone. Our neighbours, in the midst of their political difficulties and social distresses, have shown a noble example of scientific munificence, which we earnestly desire to see followed among ourselves, and we cordially wish the new telescope success.

BOTANY AND VEGETABLE PHYSIOLOGY.

Mr. Cooke's "Mycographia."—The first part of this splendid work, which is accompanied with coloured illustrations, has just made its appearance. It contains descriptions of *Geoglossum* and *Peziza*. It is published privately, and we are informed that only a very limited number of copies will be issued. Its title is "Mycographia seu Icones fungorum." It is not stated at what time

it will be concluded, but it will not be issued oftener than once in every six months. It is a work which every lover of fungi should possess.

The Atlas of Diatomaceæ.—Several parts of this excellent work have now been published, and Mr. Kitton, one of our best authorities on the subject, gives this work very high praise indeed in a notice published in "Grevillia." Certainly the plates, though a trifle rough, appear excellently executed, and they contain enormous magnifications of the objects illustrated. The number of illustrations is numerous in each part.

Influence of Nutrition on Form.—At a recent meeting of the Academy of Natural Sciences of Philadelphia, Mr. T. Meehan remarked that the influence which nutrition, in its various phases, had on the forms and characters of plants was an interesting study; and in this connection he had placed on record in the Proceedings of the Academy, that two species of *Euphorbia*, usually prostrate, assumed an erect growth when their nutrition was interfered with by an *Æcidium*—a small fungoid parasite. He had now to offer a similar fact in connection with the common Purslane (*Portulaca oleracea*), one of the most prostrate of all procumbent plants, which, under similar circumstances, also became erect.

Some new Plants from the Nicobar and Andaman Islands.– Herr S. Kurtz has a very interesting paper on this subject in the "Journal of Botany" for November 1875, from which, however, we only abstract some of the physical facts recorded. The most remarkable one is the nature of the clay. Herr Kurtz says that the interest which attaches to the Nicobar vegetation rests chiefly in the peculiar polycistine clay, which looks somewhat like meerschaum, and is also nearly as light and porous. This clay covers large areas on those islands which form the so-called northern group. It contains, according to Dr. Rink's analysis —

Silica	72·2
Oxide of iron	8·3
Alumina	12·3
Magnesia	2·1
Water	5·6
	100·5

Here the total absence of alkalies is very remarkable. In places it becomes red from abundance of oxide of iron, and in this case it is usually literally filled with fossil seaweeds. A microscopical examination of the rock reveals abundance of silica, fragments of polycistines, and diatoms. One would say that on such substrata nothing but wretched scrub and harsh grasses could vegetate; but an examination of the greater part of Kamorta has taught me that luxuriant tropical forests, with an average height of about 80 ft., not only cover the seaside, but the same forests form belts of considerable breadth over the island itself, while the inner hill plateau is covered by those peculiar park-like grasslands which Dr. Diedrichsen has called grass-heaths. The next rocks botanically influential are calcareous sea sand, raised coral banks, limestone and calcareous sandstones, which belong to the so-called southern group, in which, however, Katchall (an entirely calcareous island) is enumerated. Then come the plutonic rocks and their

detritus, which, however, were only little developed in those parts which I visited. All islands consisting of the above rocks are characterised by the absence of grass-heaths, and are covered with forests from the bottom to the top. The four principal aspects of vegetation in these islands are—1, mangrove swamps; 2, beach forests; 3, tropical forests, which fall under three groups, those growing on polycistine clay, those on calcareous or coralline strata, and those growing on plutonic formations; 4, grass-heaths.

CHEMISTRY.

The Composition of the Water of the Nile.—Mr. J. A. Wanklyn has published an interesting note in the "Chemical News" (Oct. 29, 1875) on the subject of Nile water and its varying composition. Of course our readers are aware that the Nile rises steadily to a vast height, reaching its highest level about the middle of September, and being lowest at about Christmas. The cause of the rise of the river is said to be heavy rains in the months of April and May, the effect of this rainfall requiring the lapse of a considerable time in order to exert its full influence. Possibly, too, the melting of snow on mountains near the sources of the river may concur in flooding the river. The height to which the Nile rises, as well as the exact period of the rise, varies from year to year, but it may be stated broadly that from the end of May until Christmas the Nile is more or less in flood, and from Christmas to the end of May the Nile is low. The following is a tabular statement of the composition of the water in the different months:—

Water of the Nile.

Date of Sample.			Grains per Gallon.		
			Solids.	Chlorine.	Hardness.
1874	June	8	15·0	1·80	7·0
	July	19	13·0	0·90	6·0
	Aug.	12	12·0	0·30	8·5
	Sept.	20	10·0	0·40	8·0
	Oct.	12	11·0	0·40	7·5
	Nov.	12	12·0	0·50	8·0
	Dec.	12	9·0	0·45	6·5
1875	April		16·0	1·00	8·0
	May	13	22·0	1·20	10·0

The remarkable point brought out in this table is the great relative alteration in the proportion of chlorine, that whereas in the beginning of June, just at the beginning of the rise of the Nile, the chlorine amounts to 1·8 grain per gallon the chlorine sinks to 0·3 grain per gallon when the Nile has attained a great size, and remains at very little above that proportion until the end of the year.

The Quantity of Tannin in Tea.—This question has been, with many others in relation to the chemistry of this plant, gone into by Mr. T. Wigner, whose papers have been published in the "Chemical News." The number of the "C. N." for Nov. 12, 1875, contains the author's remarks

on the tannin question. He says that the percentage of tannin in tea is very variable, and there is little doubt that this is in a great degree the cause of the erroneous estimate which English tea-drinkers frequently make of the dietetic value of tea. They prefer tea which gives a dark-coloured infusion, and has some sensible astringency, to those varieties which give a paler and less bitter liquor. This probably accounts, to some extent, for the high estimation in which some kinds of Assam are held for mixing purposes. The acetate of lead process seems more reliable for determining the percentage of tannin than the old gelatine process, and it is certainly easier. I have therefore adopted it. I find that a sample taken from a mixture of six samples of Assam tea gave 45·5 per cent. of tannin, while some of the highest results were—

	Per Cent.
No. 82. Moyune young Hyson	30·0
No. 83. Very choice Assam	33·0
No. 1. Indian young Hyson	39·0
No. 97. Assam tea from Dr. McNamara's garden .	27·7
No. 75. Caper (mixed)	42·3

GEOLOGY AND PALÆONTOLOGY.

A New Crustacean Fossil from America.—This fossil, which was exhibited by Messrs. Grote and Pitt, at a recent meeting of the Buffalo Society of Natural Science, is of much interest. The specimen shown exhibited an impression of the ventral surface of a new form of crustacean allied to *Eurypterus Pterygotus*, for which the name *Eusarcus scorpionis* is proposed. The cephalothoracic portion appears to be separate from the body, and to be considerably narrower in proportion than in allied forms. The legs are the same in number as in *Eurypterus*. The swimming feet appear to differ by the straighter, less rounded outer margins. In the specimen the rhomboidal plates are not given. From the impressions of the joints of the swimming feet their relative dimension does not seem to accord with *Eurypterus*. The four pair of anterior feet proceed from two elongate oral plates, of which the impression is very distinct. The spines of the anterior feet appear to be long curved, and to have an anterior direction. The absence of chelate appendages to the posterior margin of the feet is particularly noticeable. The first seven broad segments of the abdomen form a large ellipse. There is an evident and remarkable narrowing of the succeeding caudal segments. Of these six appear to be made out on the specimen. The surface of the cast is punctate with scattered triangular impressions. The cast shows a widening of the terminal segment, and no traces of a spiniform process are exhibited. This portion of the fossil was imbedded in the matrix, and seems to have been bent downward and outward in the specimen. The greater flexibility of the caudal segments may be inferred from their shape and position. The specimen from which the above description is drawn was found in the Water-lime group at Buffalo, N. Y., in the same bed which has furnished specimens of *Eurypterus lacustris*. The length of the entire

specimen is 250 millimeters; the greatest width of the body is 110 millimeters.

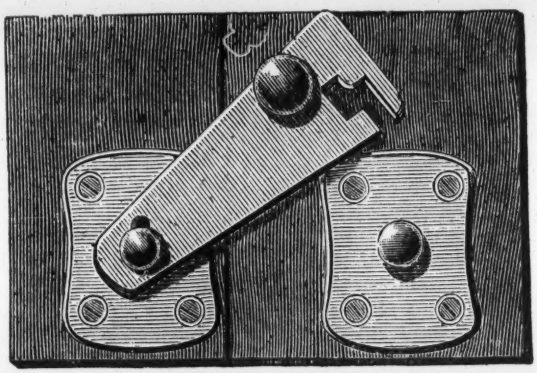
Lignite found in the Cretaceous Formation of the United States of America.—Mr. N. H. Winchell, in a letter to Mr. Dana, published in "Silliman's American Journal" (October 1875), says that an interesting discovery of lignite in the extreme northern portion of Minnesota has just been made. Explorations have been carried on during the summer by private parties in search of coal, and a hundred pounds of what was taken for coal were brought to Duluth from a point between Vermilion and Rainy lakes. Similar exploration has revealed the lignites of the Cretaceous at a number of other points in Minnesota, extending from near the Iowa State line to the central portion of the State. Mr. Kloos has given an account of a "Cretaceous basin in the Sauk Valley" in "Silliman's American Journal," and Mr. Meek identifies it as the Fort Benton by the few fossils that were gathered. Inferentially the Cretaceous has been extended over the most of Minnesota, and even into the State of Michigan ("First Annual Report of the Geological Survey of Minnesota, 1872"), but this discovery not only shows that the Sauk Valley is probably not an insolated "basin," but also that the Cretaceous beds did extend, prior to the drift, at least, if they do not now, over the entire State from north to south. He has an account also of a probable Cretaceous outcrop in the state of Winconsin from Prof. Frank H. Bradley, but it has not been identified authentically.

The Climate of the Poles, Past and Present, may not seem a very geological subject, yet it is one of the most interesting in the whole range of geological studies. A very valuable paper on this question has been contributed to the "Geological Magazine" (Nov. 1875), by Prof. Nordenskiold, in which he says that we now possess fossil remains from the polar regions belonging to almost all the periods into which the geologist has divided the history of the earth. The Silurian fossils which McClintock brought home from the American Polar Archipelago, and the German naturalists from Novaja Semlja, as also some probably Devonian remains of fish found by the Swedish Expeditions on the coasts of Spitzbergen, are, however, too few in number, and belong to forms too far removed from those now living, to furnish any sure information relative to the climate in which they have lived. Immediately after the termination of the Devonian age, an extensive continent seems to have been formed in the polar basin north of Europe, and we still find in Beeren Island and Spitzbergen vast strata of slate, sandstone, and coal, belonging to that period, in which are imbedded abundant remains of a luxuriant vegetation, which, as well as several of the fossil plant-remains brought from the polar regions by the Swedish Expeditions, have been examined and described by Prof. Heer of Zürich. We here certainly meet with forms, vast *Sigillaria, Calamites,* and species of *Lepidodendra,* &c., which have no exactly corresponding representatives in the now existing plants. Colossal and luxuriant forms of vegetation, however, indicate a climate highly favourable to vegetable development. A careful examination of the petrifactions taken from these strata shows also so accurate an agreement with the fossil plants of the same period found in many parts of the Continent of Central Europe, that we are obliged to conclude that at that time no appreciable difference of climate existed on the face of the earth,

but that a uniform climate extremely favourable for vegetation—but not on that account necessarily tropical—prevailed from the Equator to the Poles.

MECHANICS.

Browning's Patent Self-acting Latch.—One of the best—because it is at once the most efficient and withal the simplest kind of bolt that we have for some time seen—is the ingenious invention of Mr. Browning, which is figured below, and which has been recently patented. But besides its sim-



plicity, it has a special advantage, viz. that any attempt to open it from the outside renders it more securely fastened than it was before, while it registers the attempt made to open it by an alteration in its position. The bolt must be seen to be fully appreciated, and we doubt not it will soon become a most popular contrivance. It is certainly the most ingenious and yet the simplest invention in this direction that we have ever seen.

A Machine for Darning Stockings.—We have had sewing and knitting machines for some time, but the latest addition to our stock is that of a darning machine, which is described by the "Scientific American" as follows:—"Two small plates, one stationary and the other movable, are placed one above the other. The plates are corrugated, and between them the 'holy' portion of the stocking is laid. Twelve long-eyed pointed needles are arranged side by side in a frame, which last is carried forward so that the needles penetrate opposite edges of the hole, passing in the corrugations between the plates. Hinged just in front of the plates is an upright bar, and on this is a cross-piece carrying twelve knobs. The yarn is secured to an end knob, and then, with a bit of flat wire, pushed through the needle-eyes. Then the loop between each two needles is caught by the hand and hooked over the opposite knob, so that each needle carries really two threads. Now the needles are carried back to their first position, and, in so doing, they draw the threads, which slip off the knobs through the edges of the fabric. A little push forward again brings the sharp rear edges of the needle-eye against the threads, cutting all at once. This is repeated until the darn is finished, and beautifully finished it is. The cost of the machine is but ten dollars."

MEDICAL SCIENCE.

A New Cure for Sea-sickness.—This, which is the salt known as nitrite of amyl, has been recommended by Dr. C. Clapham. He says, in the "New York Medical Journal" (October 1875):—"As to the proximate cause of the malady, I entirely agree with Dr. Chapman that it consists of an undue congestion of the vessels of the spinal cord. On this point I had an excellent opportunity of drawing some conclusions from a post-mortem which I was fortunate enough to make while acting as superintendent of the Government Civil Hospital at Hong Kong last summer. The case was that of a Chinaman who had been killed while in the very act of vomiting during an attack of sea-sickness, by the fall of a heavy piece of iron from aloft. I found, on making the necropsy (four hours after death), that, leaving out of consideration the heart, which had been pierced by the falling iron, all the organs were healthy with the exception of the spinal cord, the vessels of which were literally gorged with blood throughout its entire length. I was struck with the similarity of this appearance to that presented by the spinal cord of an epileptic patient who died in the "status," and upon whom I made a post-mortem while at the West Riding Asylum, Wakefield. Coupling the post-mortem likeness to the resemblance which obtains in life between these two affections (pallor of surface, cold sweat, &c.), it occurred to me that the remedy which, in the hands of Dr. J. Crichton Brown, has proved so valuable in the epileptic "status," might be advantageously employed in the treatment of sea-sickness. To test the truth of this surmise, I made several trips across the Pacific, and tried the remedy altogether in 124 cases. Of these, 121 cases proved eminently satisfactory, there being no return of the vomiting after the administration of the nitrite; the remaining three cases being only unsatisfactory in so far as they required a further dose or two of the remedy." We fear, however, that a short experience of Dr. Clapham's remedy will show of how little use it is alone. Certes one of the best safeguards is lying perfectly recumbent (before the vessel starts) and keeping the body warm and taking a substantial meal about an hour before you set sail. The writer has tried these plans in a recent stormy passage across the English Channel, and he perfectly avoided sea-sickness. Yet on this occasion thirty or more people were violently sick, and, what is more extraordinary, he never before escaped sea-sickness in rough weather. One thing we had almost forgotten to mention, *i.e.* keep the eyes almost constantly closed, and be as nearly amid-ships as possible.

Giving Medicines to the Mother for the Suckling Infant.—Dr. Lewald has, says the "Lyon Medicale," investigated the elimination, by the milk of the mother, of iron, bismuth, iodine and its compounds, arsenic, lead, zinc, antimony, mercury, alcohol, and several narcotics. His numerous experiments were made in the goat. A certain dose of the medicine was administered to the animal, after which the milk was examined. The principal conclusions which the author has arrived at are:—1. A larger quantity of iron can be administered to the infant through the mother's milk than by any other means. 2. Bismuth likewise is eliminated by the milk, but in very small quantity. 3. Iodine does not appear in the milk until ninety-six hours after

taking it; the iodide of potassium given in doses of forty grains *per diem* appears four hours after ingestion, and continues to be eliminated for eleven days. 4. Arsenic appears in the milk at the end of seventeen hours, and its elimination had not ceased after sixty hours. 5. Though one of the most insoluble preparations, the oxide of zinc is nevertheless eliminated by the milk, and it is probable that this is also the case with the other preparations of zinc; fifteen grains of oxide of zinc were found in the milk at the end of from four to eight hours, and it disappears sooner than iron, because no trace of it could be discovered after fifteen or sixteen hours. 6. The elimination of antimony is an undeniable fact, and it is well to bear this in mind during the period of nursing; the same holds true in regard to mercurial preparations. 7. That alcohol and the narcotics are eliminated by the milk has not been demonstrated. Sulphate of quinine is eliminated very easily; a child suffering from intermittent fever was cured by administering quinine to the nurse.

METALLURGY, MINERALOGY, AND MINING.

A Mineralogical Society is likely to be formed in London, and it is undoubtedly required. Mr. J. H. Collins, who is engaged in furthering the plans of this project, has written the following letter to the "Geological Magazine" (Nov. 1875). Dating from 57 Lemon Street, Truro, he observes: "An effort is being made for the establishment of a Mineralogical Society of Great Britain and Ireland." The objects of the Society are—

To simplify mineralogical nomenclature.

To determine and define doubtful mineral species.

To study the *paragenesis* of minerals.

To record instances and modes of pseudomorphism, with their accompanying phenomena.

To measure, determine, and illustrate forms of crystallization, especially the irregularities and peculiarities of particular planes, or of crystals from particular localities.

To discuss systems of classification, and to establish a natural system.

To collect, record, and digest facts and statistics relating to economic mineralogy.

To promote the exchange of specimens; and, generally,

To advance the science of mineralogy.

The rules and regulations to be ultimately adopted will be decided upon by the votes of probably the first 100 members.

Graphite from Siberia.—M. S. Kern, of St. Petersburg, writes to the "Chemical News" (Nov. 12, 1875) as follows:—

Having lately analysed two samples of Siberian graphite from the Stepanovsky Mine, I think the results of analyses may be of some use. The Zeilon graphite containing 80 per cent. carbon, and coming from England to Russia, is far richer and cleaner, and mixed with Russian graphite is used for the manufacture of black-lead crucibles.

Analysis of Stepanovsky Graphite.

	Samples No. I. Per Cent.	No. II. Per Cent.
Carbon	36·06	33·20
Silica	37·72	43·20
Perric oxide	4·02	3·05
Alumina	17·80	15·42
Lime } Magnesia }	1·20	1·06
Volatile matter	3·20	4·03
Sulphur	traces	0·04
	100·00	100·00

METEOROLOGY.

Meteorology in England.—The report of the Meteorological Committee for 1874 has been quite recently published, and commented on by the "Academy" which says:—

The Report of the Meteorological Committee for the year 1874 has just appeared, and it shows that their office has carried out steadily work of the same nature as in former years. As regards marine meteorology, the number of observers remains small compared with the strength of our merchant navy, but the quality of the observations which are received appears to be good. The investigation of the nine 10-degree squares lying close to the equator in the Atlantic, is nearly complete, and monthly charts for this region will shortly appear. The next district to be attacked by the office is the south point of Africa.

The results of storm-warnings are much the same as in 1873, nearly 80 per cent. of the warnings having been justified by subsequent weather, and more than half of that proportion having been followed by serious storms.

In the land meteorology of the United Kingdom some important changes are noticed in the announcement of the satisfactory conclusion of arrangements for co-operation between the office and the Meteorological Society (of London), in virtue of which the Society will supply returns from certain selected stations for publication *in extenso* by the office in conjunction with returns from its own volunteer observers, and in accordance with the international plan proposed by the Permanent Committee of the Vienna Congress, which has already been noticed in these pages.

When the vote for learned societies was taken in the House of Commons, Mr. Maclagan moved its reduction by the sum of 1,000*l.*, this amount to be transferred from the Meteorological Office to the Scottish Meteorological Society, and was defeated; but Mr. Smith, on the part of the Treasury, stated that it was the intention of that department to institute an inquiry into the meteorological organisations of the country in the course of the autumn.

All meteorologists will hail this announcement as most satisfactory, as no such inquiry has ever yet been held except that before the Commission on

the Advancement of Science now just closed, for the committee appointed in 1865 only reported on the state of the Meteorological Department of the Board of Trade.

The Report of the Commission just mentioned has also appeared, and has been noticed in our columns; but, as it goes at some length into the subject of Meteorology and the condition of the Meteorological Office, it may be allowable to refer again to its contents. The commissioners for the most part content themselves with reproducing the opinions of some of the gentlemen who have given evidence before them. In their remarks on the evidence, however, they say (p. 25):—

"With respect to meteorology, we are of opinion that the operations of the Meteorological Office have been attended with great advantage to science and to the country. The subject of Meteorology is a very vast one, and any scheme for its proper cultivation or extension must comprise—(1) arrangements for observing and registering meteorological facts; (2) arrangements for the reduction, discussion, and publication of the observations; (3) researches undertaken for the purpose of discovering the physical causes of the phenomena observed. The resources placed at the disposal of the committee are inadequate to cover the whole of this wide field; and, having due regard to all the circumstances of the case, we believe that in selecting parts of it, as the objects of their special attention, they have been guided by a sound discretion.

"We are also disposed to consider that although, as we have already said, the Meteorological Committee occupies an anomalous position, no other form of organisation could advantageously have been adopted under the actual conditions. We think, however, that if, as we shall hereinafter recommend, a Ministry of Science should be established, the head of the Meteorological Office should be made responsible to the minister."

The Commissioners further comment upon the views held by Professor Balfour Stewart and others, to the effect that climatological inquiries should be left to the efforts of local societies aided by Government; and while acknowledging the usefulness of the results already yielded by such systems in the United Kingdom—*e.g.* that of Mr. Glaisher and that of the Scottish Meteorological Society—they express their opinion that any grants in aid should be made on a systematic principle, which could best be effected by making them subject to the control of a minister.

MICROSCOPY.

Microscopical Papers for the Quarter.—The following articles have appeared in the "Monthly Microscopical Journal" for October, November, and December:—

On Cephalosiphon and a New Infusorion. By Dr. C. T. Hudson, LL.D.—Recent Progress of our Knowledge of the Ciliate Infusoria. By G. J. Allman, M.D., F.R.S.—Extracts from Mr. H. E. Fripp's Translation of Professor Abbe's Paper on the Microscope.—On a New Melicerta. By C. T. Hudson, LL.D., F.R.M.S.—On the Identical Characters of

Chromatic and Spherical Aberration. By Dr. Royston-Pigott, M.A., F.R.S.—Perforating Proboscis Moths. By Henry J. Slack.—Trochosphæra Æquatorialis, a Spherical Rotifer found in the Philippine Islands. By Herr Semper.—Extracts from Mr. H. E. Fripp's Translation of Professor Abbe's Paper on the Microscope.—On a New Method of Measuring the Position of the Bands in Spectra. By H. C. Sorby, F.R.S., &c., Pres. R.M.S.—Note on the Markings of Frustulia Saxonica. By Assistant-Surgeon J. J. Woodward, U.S. Army.—Appendix to the Paper on the Identical Characters of Spherical and Chromatic Aberration. By Dr. Royston-Pigott, F.R.S., &c.—The Slit as an Aid in Measuring Angular Aperture. By Professor R. Keith.

PHYSICS.

Death of Sir Charles Wheatstone.—Physical Science has sustained the deepest possible loss by the death of Sir Charles Wheatstone, F.R.S., which took place at Paris, at the Hôtel du Louvre, on October 20, 1875. Identified as he was with the practical development of telegraphy, the name of Wheatstone was familiar to all, and the fact of the later years of his life having been devoted to subjects connected with electricity has led even the scientific world to lose sight of his valuable work in other branches of physics. As early as 1823, while engaged in the manufacture of musical instruments, Charles Wheatstone published a paper on "New Experiments on Sound," and on looking through the list of his published papers one recalls the value of his experiments in connection with sound and light. Still it is as the electrician that Wheatstone rose to the first rank in science, and, as we have already said, it is the conspicuous part he played in the invention and application of the electric telegraph that raised him so high in popular esteem. In 1834 Professor Wheatstone was appointed Professor of Experimental Philosophy at King's College. In 1836 he was elected a Fellow of the Royal Society, when he read a paper entitled "Contributions to the Physiology of Vision," and this led to the invention of the stereoscope, which he first exhibited at the meeting of the British Association for the Advancement of Science in 1838. In 1868 Wheatstone was knighted in recognition of his scientific services, but thirteen years before the Emperor of the French had appointed him a Chevalier of the Legion of Honour on account of his application of the electric telegraph. He was also a Member of the French Academy. A list of his principal papers, contributed to scientific societies and journals, has been published in the "Chemical News," where it occupies nearly a whole column.

Experiments on the Ultra-Violet of the Spectrum.—In a late number of the "Comptes Rendus" (October 18), M. Croullerois states that in order to effect the measurement of the rotatory power of quartz in the ultra-violet of the spectrum, he had recourse to the procedure of Mr. Stokes, and made use of the analytical method of MM. Fizeau and Foucault; but, notwithstanding the most favourable atmospheric conditions, it was impossible for him to carry the measurement of the rotations beyond the ray O. It is true that in his experiments the normal ultra-violet spectrum, and the interference band, were seen by reflection on paper saturated with the fluorescent

solution, the eye interfering only in a secondary mannner in the observation of the phenomenon. When M. Soret made known to the author his fluorescent eye-piece, with which the spectrum may be regarded under conditions of direct transmission, apparently more favourable, he pointed out to him this application of his ingenious instrument. The author has noticed, in the "Comptes Rendus" of October 11, a paragraph showing that this application has been successfully tried by MM. Soret and Sarazin; but these physicists have not been able to extend their observations beyond the ray N, which shows that the absorption by transmission is still more injurious than the loss of light by epipolic dispersion.

ZOOLOGY AND COMPARATIVE ANATOMY.

The Anatomy of the Giraffe.—Although this subject has been examined before by Professor Owen, F.R.S., Dr. H. C. Chapman has published some observations on it before the Academy of Natural Sciences of Philadelphia. They were made upon an animal which died a short time ago in the Philadelphia Zoological Gardens. He had pleasure in saying that he found the internal organs as described by Professor Owen, save in reference to the manner in which the great blood-vessels spring from the aorta. In the example dissected by Dr. Chapman there was an innominate artery which gave off the left subclavian, the right subclavian, the right vertebral and the common trunk of the carotids, the left vertebral springing alone from the aorta; whereas in Professor Owen's example, according to the description, the left subclavian, as well as the left vertebral, came off separately from the aorta, while the right vertebral came from right subclavian. It is possible that in the former the disposition of the blood-vessels was an anomalous one. He would also mention that there was an entire absence of a gall-bladder, which was noticed twice out of three times in the cases studied by Professor Owen. For the reason above given he did not refer to the brain, alimentary canal, &c.; to those who may be interested, he would simply state that these organs may be seen in the museum of the University of Pennsylvania.

The Meteorological Aspects of the Flight of Grasshoppers.—In some parts of the Southern States of America great flights of grasshoppers take place at certain seasons; and a curious fact has been recently observed in connection with their flight, which would seem to give them the power of forecasting the state of the weather. Mr. J. Wilson states that lately, on a cloudy afternoon, the insects were on the wing, high in the air, in countless multitudes. A party of several persons was riding in a carriage, and the question of probable rain was discussed. Suddenly the grasshoppers, with great unanimity, descended to the ground, the scene reminding one of a furious snowstorm. In two or three minutes no grasshopper could be seen in the air, and in a short time it commenced to rain. Soon after the rain ceased to fall the insects took flight again, but in the course of half an hour, without any particular indication of rain, they suddenly plunged to the earth again. Soon after this it rained again. This process was repeated three times on that afternoon, and each descent was followed by a fall of rain.

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